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The
# Practical Engineer

**A monthly journal, devoted to the economical generation and utilization of power and to the interests of stationary engineers**

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## STEAM ENGINE FLY-WHEELS

### Methods of Design and Construction

In a single-cylinder engine of the cut-off type, the full pressure of the boiler is only acting on the piston up to the point of cut-off, after which constantly reducing pressures are being exerted until release takes place, so that the power which the cylinder is giving out is a constantly varying quantity. This is further complicated by the fact that during the first part of the stroke, the crank is in a position where it cannot do effective work. These variations of efforts on the crank pin are still further complicated when the outside resistance or work which the engine must perform is also varying.

It is the function of a fly-wheel to take care of all these inequalities of turning moment and smooth them out so that the variation in speed during one revolution shall be kept within any assigned limits. A fly-wheel, therefore, serves to store up work and give it out when required, just as a mill-pond fed by a stream of variable discharge serves to store up water for the mill-wheel; the larger the pond, the less the effect of any sudden increase or decrease of the amount of water flowing into it. The same is true with the fly-wheel; the larger it is and the more rapid its motion, the more steadily it will run, so that generally speaking, it would hardly be possible to make the fly-wheel too large or too heavy, were it not for the great cost and increased friction on the bearings.

It is impossible, however, to control the speed of any engine for any considerable length of time by means of a fly-wheel; the governor must do that; but it is possible with a properly designed fly-wheel to confine the variations of the speed during the time of one stroke within any predetermined coefficient of steadiness.

The function of a fly-wheel is, therefore, to store up excess of energy received from the piston in one part of the stroke and to give it out when the effort shall have grown less by expansion. Secondly, to equalize variation in the leverage with which the varying steam effort acts upon the crank to revolve the shaft, and thirdly, to give out and absorb energy when variation in the external load occurs suddenly.

For permanent variations in the load, the capacity of the fly-wheel as a regulator is soon exhausted and the engine will either increase or diminish its speed. The governor must then adjust its mechanism to bring the engine back to speed and adjust the amount of steam admitted to the new amount of work done. Where loads quickly vary, as in electric railway power plants, it will often be found that the ammeter will vary several hundred amperes without the governor being affected. This is to be explained by the action of the fly-wheel and the absorption and giving out of energy under such instantaneous variations.

The weight of a fly-wheel must be largely determined by

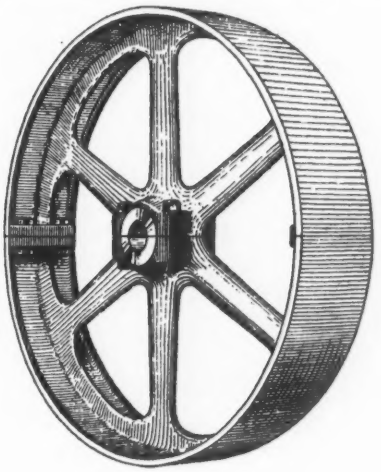

Fig. 1.

the character of the work which an engine must perform. A weight capable of equalizing and steadying the variations of the load in some plants would not be enough to serve as a necessary reservoir of power when heavy demands are made on it, as in a rolling mill. In the latter case, when the rolls are empty, there will only be the friction of the machinery, but when the piece of iron is going between the passes, the maximum power of the engine is required. Rolling mill engine fly-wheels, therefore, have a weight of from thirty to fifty tons to meet this requirement and in electric-railway practice and in slow-speed pumping engines, very massive fly-wheels are used.

In the design of a fly-wheel, the weight required to produce

a certain degree of steadiness is usually considered as being concentrated in the rim. While it is not very often that an engineer is called upon to design a fly-wheel, it might be well to give a few of the formula governing the design, as given

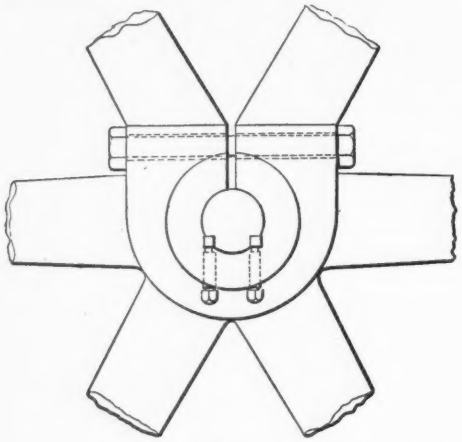

Fig. 2.

by the best authorities. Prof. Thurston gives for engines with automatic valve gear,

$$W = 250{,}000 \frac{ASp}{R^2D^2}$$

in which A = area of the piston in square inches, S = stroke in feet, p = mean steam pressure in pounds per square inch, R = revolutions per minute and D = outside diameter of wheel in feet. Mr. F. M. Rites gives his formula as follows:

$$W = \frac{C \times H.\ P.}{R^2D^2}$$

in which C varies from 10,000,000,000 to 20,000,000,000 in single-acting engines of the Westinghouse type and 5,000,000,000 for double-acting engines in ordinary service. The values of H. P., R and D refer respectively to horse power, revolutions per minute, and diameter of the fly-wheel in feet. Mr. J. B. Stanwood gives the formula:

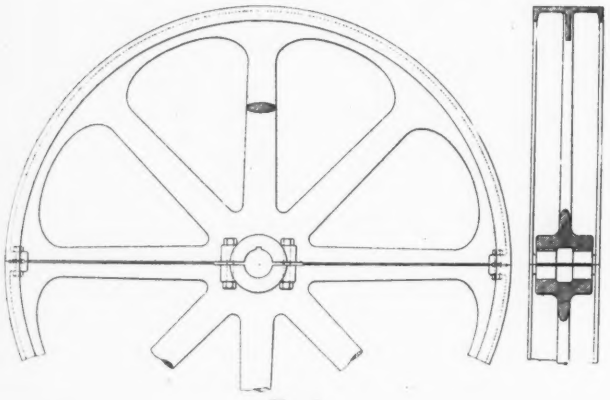

Fig. 3.

$$W = c \frac{d^2s}{D^2R^2}$$

in which W = weight in pounds, c = coefficient of steadiness, d = diameter of cylinder in inches, s = length of stroke in inches, D = diameter of the wheel in feet, R = revolutions per minute. The values of c depend upon the kind of engine and duty it must perform. For slide valve engines, ordinary duty, c = 350,000; slide valve engines for electric lighting, c = 700,000; for automatic high-speed engines, c = 1,000,000, for Corliss engiher, ordinary duty, c = 70,000 and for electric lighting, c = 1,000,000.

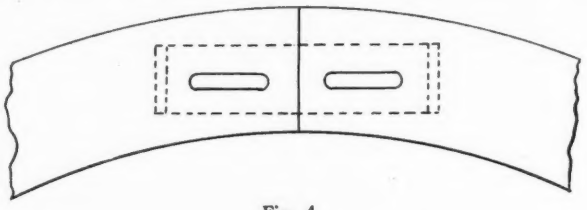

Fig. 4.

In compound engines where the cranks are 90 degrees apart or in triple expansion engines where the cranks are 120 degrees apart, the weight of the rim of the fly-wheel can be considerably reduced owing to the fact that the shaft has a more equal turning moment due to one of the cranks always being in an effective turning position. In a single-cylinder engine there are only four points in one revolution where the work given out by the cylinder and that absorbed by

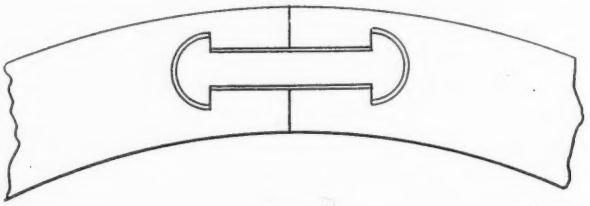

Fig. 5.

the fly-wheel are equal. During the remainder of the revolution, either the fly is absorbing work from the cylinder or it is giving its absorbed work to the outside resistance. With engines having two cranks at 90 degrees, there are eight points where the work absorbed by the fly-wheel is equal to that given out by the cylinders and in engines having their cranks 120 degrees apart, there are twelve points of equality, so that it can be seen that in the latter classes of engine, the fly-wheel does not have to handle the inequalities

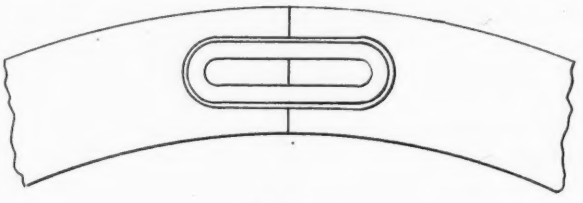

Fig. 6.

of work over such a great portion of the revolution as in a single engine.

In the design of a fly-wheel there are two important features that enter into its ability for producing steadiness and they are the diameter of the wheel and the speed of the engine. If the speed of engine is high, the diameter of the fly-wheel must be made comparatively small, since it is not advisable to

carry the speed of the rim beyond a certain limit owing to the strains in the rim caused by the centrifugal force, which is proportional to the diameter of the wheel and square of the speed. It has, therefore, been found in practice that cast-iron fly-wheels should not exceed a maximum velocity of 6000 feet per minute and where there is likely to be any initial strains in the wheel caused by shrinkage in casting, as would occur in a large cast-iron fly-wheel, the speed should not exceed 5000 feet per minute. If 6000 feet per minute be the maximum of rim allowable, then $6000 = 3.1416\ RD$, in which R = revolutions per minute and D = diameter of wheel in feet, from which $D = 1910 \div R$. Based upon the formula, the following table has been compiled:

MAXIMUM DIAMETER OF FLY-WHEEL ALLOWABLE FOR DIFFERENT NUMBERS OF REVOLUTIONS.

| Revolutions per Minute. | Max. Speed of 5000 Rev. per Minute. | | Max. Speed of 6000 Rev. per Minute. | |
|---|---|---|---|---|
| | Circum.—Ft. | Diam.—Ft. | Circum.—Ft. | Diam.—Ft. |
| 40 | 125 | 39.8 | 150 | 47.7 |
| 50 | 100 | 31.8 | 120 | 38.2 |
| 60 | 83.3 | 26.5 | 100 | 31.8 |
| 70 | 71.4 | 22.7 | 85.7 | 27.3 |
| 80 | 62.5 | 19.9 | 75.0 | 23.9 |
| 90 | 55.5 | 17.7 | 66.6 | 21.2 |
| 100 | 50 | 15.9 | 60.0 | 19.1 |
| 120 | 41.6 | 13.3 | 50.0 | 15.9 |
| 140 | 35.7 | 11.4 | 42.8 | 13.6 |
| 160 | 31.2 | 9.9 | 37.5 | 11.9 |
| 180 | 27.7 | 8.8 | 33.3 | 10.6 |
| 200 | 25.0 | 8.0 | 30.0 | 9.6 |
| 220 | 22.7 | 7.2 | 27.3 | 8.7 |
| 240 | 20.8 | 6.6 | 25.0 | 8.0 |
| 260 | 19.2 | 6.1 | 23.1 | 7.3 |
| 280 | 17.8 | 5.7 | 21.4 | 6.8 |
| 300 | 16.6 | 5.3 | 20.0 | 6.4 |
| 350 | 14.3 | 4.5 | 17.1 | 5.5 |
| 400 | 12.5 | 4.0 | 15.0 | 4.8 |
| 450 | 11.1 | 3.5 | 13.3 | 4.2 |
| 500 | 10.0 | 3.2 | 12.0 | 3.8 |

A fly-wheel does not, however, consist of a simple annular ring revolving around its geometric axis. It always consists of a rim, either solid or segmental, to which are attached a number of arms. These arms tend to prevent any enlargement of the rim when the wheel is revolved and are therefore in tension. If the wheel rim was composed of a number of segments, each independent of one another, then it would be necessary to proportion the arms for direct tension due to the outward pull on each segment under the action of centrifugal force alone, but in practice this is not the case, as there is always some bending of the arms due to the pull of the rim which is always taking place due to varying amounts of work given to it by the steam cylinder. The arms are therefore usually elliptical, cross or I-section with the long axis in the direction in which the wheel turns. The elongated section gives strength against the distortion of the rim as the speed varies and also gives the least resistance to rapid motion through the air. The arms are carefully tapered from hub to rim and are joined to both the hub and rim by wide, generous fillets, as shown in Fig. 1. When the wheel is made in one piece, it is either forced on the shaft and keyed, or it is made with a split hub and clamped on the shaft with bolts. Fig. 2 shows an arrangement of this latter kind used on the Ball and Wood engine. The hub is split on one side, and a bolt which passes through two of the arms clamp the hub to the shaft. The keys are square with parallel sides and are inserted without driving. When the wheel has been firmly clamped on the shaft, set screws are clamped down tight on the keys to keep them in place.

The difficulty connected with the shipment of heavy wheels in one piece and the large amount of contraction in cooling large wheels after they are cast has resulted in making the wheels in halves, as shown in Figs. 1 and 3. This is also a convenience when erecting the engine. The wheel is usually split between the spokes and the plane of the joints at the hub and the rim is usually different, so that the bolt strains may not be entirely axial in both the hub and rim bolts at once.

For wheels of still larger diameter and heavier weight, a segmental construction of wheel is used both for convenience of shipment, handling, erection and avoidance of shrinkage strains due to casting large wheels. A fly-wheel, which does not have to be used for a band wheel, has a rim somewhat generally rectangular in section with one arm and a segment of the rim cast in one piece. The inner ends of the arms are inserted in sockets in a massive hub to which they are secured by transverse keys. The rim segments are joined together by carefully fitting the ends and are held in place by one of several different kinds of joints.

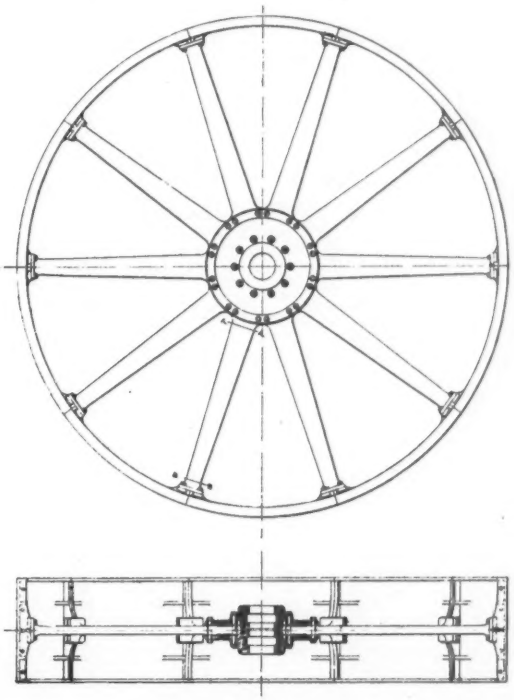

Fig. 7.

One method for making the joint is to cut recesses in the interior of the rim and insert a piece of wrought-iron into the recesses of both segments, taper keys or carefully fitted bolts being used to keep this piece of wrought-iron a prisoner. This form of joint is shown in Fig. 4. Even better than this is the use of wrought-iron or steel prisoners which are inserted when redhot into the recesses of the rim, so that their contraction on cooling will draw the joint firmly together. These prisoners may be of sections in the form of an I, as

shown in Fig. 5, or they may be of the shape of an oval link, as shown in Fig. 6. The recesses which they fit enable them to be hammered solid while hot and their hold upon the bosses forms the joint.

When the fly-wheel is to serve as a belt wheel or in rope driving, the rim requires it to be wide rather than deep. Such wheels will generally be of large diameters, since the linear speed of belts or ropes should be high. Such band wheels are made as shown in Fig. 7. The arms are securely bolted to the rim segments and are held at the shaft between the flanges of the hub, the entire bolting of the wheel being by means of turned bolts accurately fitted and driven into reamed holes. Ample strength is given to the bolts to resist the greatest possible strain that may come upon them. Each arm ends in a sort of pad which forms the bearing surface for the bolts which unite the ring segments to the arms and to each other.

When great width of fly-wheel is necessary, as with engines of large powers, more than one set of arms becomes necessary

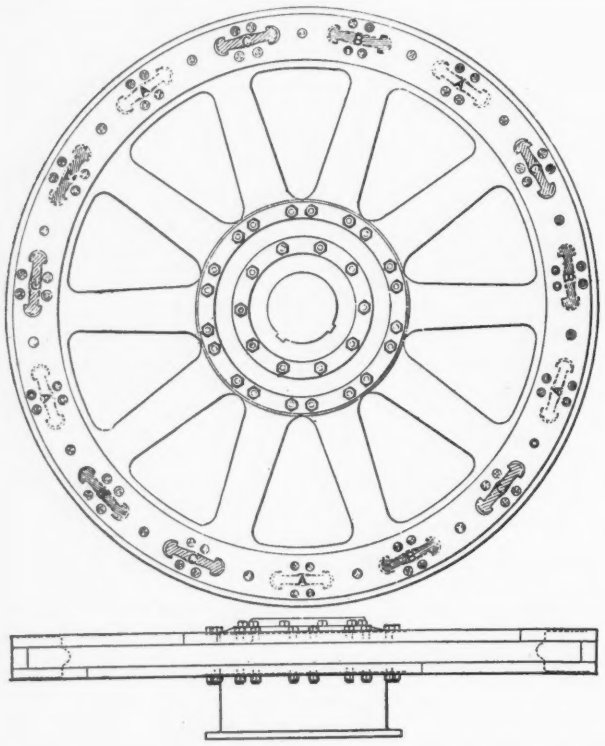

Fig. 8.

to prevent side flexure of the rim. They are then built up in sections and bolted together. Very heavy fly-wheels are now also being built in sections, an example of which is shown in Fig. 8. The centre is made of cast-iron and the arms and ribs of cast-steel. The rim is made up in width of three thicknesses, a central portion carried by the arms 12 inches in width, to which are riveted on each side plates or segments 6½ inches in thickness. The central portion is cast in five segments, each consisting of two arms and one-fifth of the rim. They are joined by links shrunk into pockets in the sides, as at AAAA, Fig. 8, and are bolted into the hub, making a cast-steel fly-wheel 28 feet in diameter and 12 inches face. Then upon each side of the rim of this fly-wheel are riveted segments 6½ inches in thickness and of width corresponding to the thickness of the rim with a half-inch bead around the outer edge, each going one-fifth of the way around the wheel, increasing the face to 26 inches. Besides being attached to the wheel by 3¼-inch rivets, these segments are attached to each other by links, just as are the segments of the main wheel, the segments being so placed as to break joints; those on one side being at B B B B and the others at C C C C C. This gives practically three rings running together, each self-supporting as to the centrifugal force. A wheel of this kind will usually have about 100 tons of metal in the rim and can be run up to 6600 feet or one and one-quarter miles a minute.

Locomotives and marine engines require no fly-wheels, since the energy stored in the moving boat or train serves this purpose. For rough work in furnaces and rolling mills, where the engine must often be rapidly reversed or stopped quickly, the fly-wheel is often dispensed with, in which case there must be at least two cranks which are quartered. Large fly-wheels for stationary engines usually have notches in their circumference, so that a bar can be inserted in order to pry them over the centres and put the cranks in an effective position for starting.

### Fly-Wheel Accidents During April.

While the number of boiler explosions which occur each year are often given, the number of fly-wheel accidents are not so easy to tabulate, owing to the many and various kinds of accidents which occur daily. A few of the accidents reported during April are as follows:

On April 2d, Chas. Rose, employed as engineer at the Covington Co.'s mill, at Kent, Wash., was killed by the bursting of a fly-wheel. Seeing that the engine was running away, Mr. Rose attempted to reach the throttle, when the large wheel, which had gained excessive speed, flew to pieces, killing him instantly.

On April 6th, the big fly-wheel of the engine which runs the sheet mill of the American Sheet and Tin Plate Co., at South Sharon, flew to pieces and big damage was done to the plant.

On April 10th, a fly-wheel in the Medart Patent Pulley Co.'s plant, at St. Louis, Mo., broke from its fastenings and injured one man.

On April 12th, a 10-ton fly-wheel, 24 feet in diameter, burst in the National Rolling Mill, at McKeesport, Pa., and the pieces wrecked the entire mill.

On April 13th, at Geneva, Ill., the bursting of a saw and its fly-wheel, while going at a rate of 700 revolutions, caused a $500 loss at Cannon Box Works.

On April 16th, the flying fragments of a bursting wheel in the sawmill of Wm. H. Radcliffe, at Centreville, Md., seriously injured one of the workmen.

On April 25th, at Elba, Mich., a fly-wheel weighing 1600 pounds was thrown through the ceiling of John Smith & Co.'s elevator, doing considerable damage.

On April 26th, Floyd Compton was instantly killed at Bolivar, N. Y., as the result of an explosion of the fly-wheel of a gas engine.

One-sixth of the tensile strength of plate, multiplied by thickness of plate and divided by one-half the diameter, gives safe working pressure for tubular boilers.

# USEFUL INFORMATION ABOUT THE CIRCLE

By Wm. Kavanagh.

A circle may be defined as a figure or portion of a plane bounded by one continuous curved line equidistant in every direction from a point within it called the centre and it is probably one of the most important figures that an operating engineer has to deal with.

Referring to Fig. 1, A is the centre and the curved line B, C, P, etc., is called the circumference. The line DAP is called the diameter and the lines AB, AD, AP, AN are called *radii*, which is the plural for radius, hence the radius equals half the diameter. The line MN is called the chord and the curved line MEN is called an arc. The portion of the circle bounded by the straight line MN and the curved line MEN is called the segment. The portion of the circle bounded by the curve NP and the radii AN and AP is called a sector.

Every circle is divided into 360° (written 360 degrees); therefore, one degree is the one-three hundred and sixtieth part of the circle. Referring to Fig. 2, when the diameters are drawn so as to divide the circle into four equal parts, each of the parts will contain 90° and are called right angles; thus the angles AOC, AOD, ACB and ADB are all right angles. If we now bisect or halve a right angle, an angle of 450° is obtained, as the angles ACK, AKB. If a right angle is divided into three equal parts, each angle will contain 30 degrees and is called the trisection of a right angle.

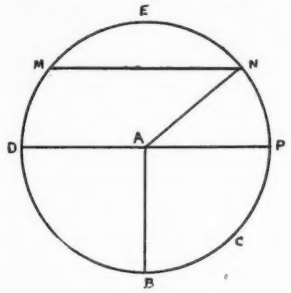


Fig. 1.

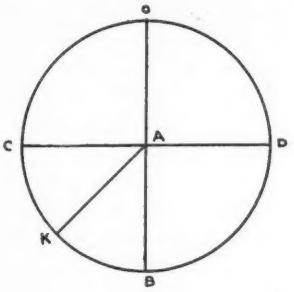


Fig. 2.

The area of a circle can be found in numerous ways but the three following formulæ are used most:

$$A = R^2 \times 3.1416 \quad (1)$$

$$A = D^2 \times .7854 \quad (2)$$

$$A = (R \times C) \div 2 \quad (3)$$

in which R = radius of circle, D = diameter and C = circumference. The small numeral 2 written above R and D in formulas (1) and (2) is called an "exponent" and means that the letter or number over which it is written should be multiplied by itself; thus $R \times R = R^2$, and if $R = 2$, then $2 \times 2 = 4$. This is also called "squaring." In formula (2), it can be seen that D must be "squared," then $D \times D = D^2$ and if $D = 4$, then $4 \times 4 = 16$. In formula (3), the radius R must be multiplied by the circumference and the product divided by two. Suppose it is required to find the area of a 4-inch safety valve. Then by using formula (1) we have

$$A = 2 \times 2 \times 3.1416 = 12.5664$$

Using formula (2) we have

$$A = 4 \times 4 \times .7854 = 12.5664$$

and formula (3) becomes

$$A = 2 \times 12.5664 \div 2 = 12.5664$$

all of which give the same result.

There is one thing to be noticed about formula (3); it has the same shape as the formula for the area of a triangle. To find the area of a triangle, the base is multiplied by the height and the product divided by two. Referring to Fig. 4, ABC is the triangle, AB its base and Ca its height. To find the area of this triangle, the length of the line AB is multiplied by the line Ca and the product divided by two; hence every circle can be considered the same as a triangle having a curved base and an altitude equal to the radius. A very simple way to prove this is to roll a circle of a given diameter along a plane surface and note the distance traversed by the circle. In one complete revolution, a line will be obtained equal in length to the circumference of the given circle. Call this line the base of the triangle and multiply it by half the diameter and divide by two, and the area of the circle will be obtained.

In passing a first-class examination for an engineer's license, the following question may be asked: "How will you find the area of a segment of your boiler head?" Referring to Fig. 3, the segment required to be found has the shape AMB and is the area bounded by the chord and the arc. A simple

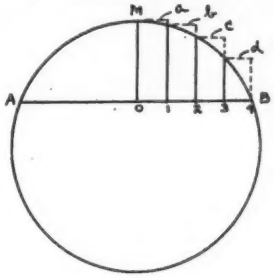


Fig. 3.

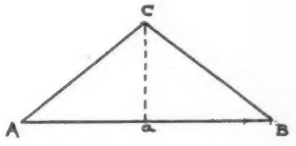


Fig. 4.

and easy way for doing this problem is to divide the cord AB into two equal parts as at O and draw OM perpendicular to AB. Now divide OB or OA in any number of equal parts and erect the lines 1, 2, 3, 4, terminating in the circumference as shown. This will divide OMB into a given number of parallelograms leaving outside the circumference the small triangles a, b, c, d. Now find the area of each parallelogram, which is obtained by multiplying its height by its width, and subtract the area of each triangle from the parallelogram to which it belongs. Now add the areas so found multiplying this sum by two and the result will be the area of the segment AMB.

There are other and more exact methods to employ in finding the area of a segment but the above method is simple and easily memorized. It is important to know how to find the area of a segment in order to determine the number of braces and load on any part of the boiler head, besides, if this length be multiplied by the length of the boiler, the volumetric relation between the water and steam space can be obtained.

# How to Calculate the Horse Power of Steam Boilers

By Chas. J. Mason.

Without going into an explanation of the term "horse power" as applied to boilers, I will at once take up the methods of operation of finding the horse power, for it seems to me that there are many operating engineers who do not quite understand how to go about such calculations.

In the first place there are two methods in general use; one, which is based upon the amount of heating surface contained in any given boiler and the other, which is based on the quantity of water which can be evaporated in a given time.

The heating surface method answers very well, commercially, as a buying and selling medium, but the evaporative test is the standard and, of course, is considered the most nearly correct. It has been found by experience and experiment that a certain number of square feet of heating surface in certain boilers is capable of furnishing one horse power. The figures range from 9 to 15 square feet, according to the type of boiler and the average conditions of operation surrounding each. Heating surface means all that surface in a boiler on one side of which is water and on the other the heat of the fire or the gases of combustion.

Now some engineers find it difficult to calculate the heating surface of a boiler so therefore I will take an example and show how to proceed with the calculations. If the problem is stated as follows, there should be no difficulty in solving any problem if the same method of calculation is followed.

Let us suppose that we have a horizontal return tubular boiler of the following dimensions and that the horse power of the same is required on the heating surface basis: The diameter is 54 inches and it is 10 feet long; there are 74 tubes, 2 inches inside diameter and 10 feet long.

The calculations can then be made like this:

Circumference of shell $= 54 \times 3.1416 = 169.65$ inches.

Length of shell $= 10 \times 12 = 120$ inches.

Heating surface of shell $= 169.65 \times 120 \times {}^{2}/_{3} = 13{,}572$ square inches.

Circumference of tubes $= 2 \times 3.14 \times 120 \times 74 = 55{,}766$ square inches.

Area of one head $= 54^2 \times .7854 = 2{,}290$ square inches.

${}^{2}/_{3}$ area of both heads $= {}^{2}/_{3} \times 2 \times 2{,}290 = 3{,}053$ square inches.

Area through tubes $= 2^2 \times .7854 \times 74 = 232$ square inches.

Tube area both ends $= 2 \times 232 = 464$ square inches.

$$\text{Total heating surface} = \frac{13{,}572 + 55{,}786 + 3{,}056 - 464}{144}$$

$$= 499.49 \text{ square feet.}$$

Horse power of boiler will then be $499.49 \div 15 = 33.29$, taking the rating of a horizontal return tubular boiler at 15 square feet of heating surface equals one horse power. A reading of the foregoing calculations will make it unnecessary to explain the individual operations.

The same method may be applied to any other type of boiler by applying the proper divisor. For instance, if it were a water-tube boiler which is to be considered, the final divisor would be 12, as 12 square feet of heating surface is usually taken as an equivalent to one horse power in that type of boiler. Of course, in a water-tube boiler, it would be more difficult to calculate the area of the headers into which the tubes are expanded, because of their irregular form, but an approximation only would be all that would be actually required.

In order to have an accurate standard of boiler power, the

## Table of Properties of Saturated Steam

| Gauge Pressure per Square Inch, in Pounds | Pressure Above Vacuum per Square Inch in Pounds | Temperature in Degrees F. | Total Heat in Heat Units at 32 Degrees F. | Heat in Liquid from 32 Degrees in Heat Units | Heat of Vaporization or Latent Heat in Heat Units | Density or Weight of 1 Cubic Foot in Pounds | Volume of 1 Pound in Cubic Feet | Factor of Equivalent Evaporation from and at 212 Degrees F. |
|---|---|---|---|---|---|---|---|---|
| .... | 1 | 101.99 | 1113.1 | 70.0 | 1043.0 | 0.00299 | 334.50 | 0.9661 |
| .... | 2 | 126.27 | 1120.5 | 94.4 | 1026.1 | 0.00576 | 173.60 | .9738 |
| .... | 3 | 141.62 | 1125.1 | 109.8 | 1015.3 | 0.00844 | 118.50 | .9786 |
| .... | 4 | 153.09 | 1128.6 | 121.4 | 1007.2 | 0.01107 | 90.33 | .9822 |
| .... | 5 | 162.34 | 1131.5 | 130.7 | 1000.8 | 0.01366 | 73.21 | .9852 |
| .... | 6 | 170.14 | 1133.8 | 138.6 | 995.2 | 0.01622 | 61.65 | .9876 |
| .... | 7 | 176.80 | 1135.9 | 145.4 | 990.5 | 0.01874 | 53.39 | .9897 |
| .... | 8 | 182.92 | 1137.7 | 151.5 | 986.2 | 0.02125 | 47.06 | .9916 |
| .... | 9 | 188.33 | 1139.4 | 156.9 | 982.5 | 0.02374 | 42.12 | .9934 |
| .... | 10 | 193.25 | 1140.9 | 161.9 | 979.0 | 0.02621 | 38.15 | .9949 |
| .0 | 14.7 | 212.00 | 1146.6 | 180.7 | 966.0 | 0.03793 | 26.78 | 1.0000 |
| .03 | 15 | 213.03 | 1146.9 | 181.8 | 965.1 | 0.03826 | 26.14 | 1.0003 |
| 5.3 | 20 | 227.95 | 1151.5 | 196.9 | 954.6 | 0.05023 | 19.91 | 1.0051 |
| 10.3 | 25 | 240.04 | 1155.1 | 209.1 | 946.0 | 0.06199 | 16.13 | 1.0099 |
| 15.3 | 30 | 250.27 | 1158.3 | 219.4 | 938.9 | 0.07360 | 13.59 | 1.0129 |
| 20.3 | 35 | 259.19 | 1161.0 | 228.4 | 932.6 | 0.08508 | 11.75 | 1.0157 |
| 25.3 | 40 | 267.13 | 1163.4 | 236.4 | 927.0 | 0.09644 | 10.37 | 1.0182 |
| 30.3 | 45 | 274.29 | 1165.6 | 243.6 | 922.0 | 0.1077 | 9.285 | 1.0205 |
| 35.3 | 50 | 280.85 | 1167.6 | 250.2 | 917.4 | 0.1188 | 8.418 | 1.0225 |
| 40.3 | 55 | 286.89 | 1179.4 | 256.3 | 913.1 | 0.1299 | 7.698 | 1.0245 |
| 45.3 | 60 | 292.51 | 1171.2 | 261.9 | 909.3 | 0.1409 | 7.097 | 1.0263 |
| 50.3 | 65 | 297.77 | 1172.7 | 267.2 | 905.9 | 0.1519 | 6.583 | 1.0280 |
| 55.3 | 70 | 302.71 | 1174.3 | 272.2 | 902.1 | 0.1628 | 6.143 | 1.0295 |
| 60.3 | 75 | 307.38 | 1175.7 | 276.9 | 898.8 | 0.1736 | 5.760 | 1.0309 |
| 65.3 | 80 | 311.80 | 1177.0 | 281.4 | 895.6 | 0.1843 | 5.426 | 1.0323 |
| 70.3 | 85 | 316.02 | 1178.3 | 285.8 | 892.5 | 0.1951 | 5.126 | 1.0337 |
| 75.3 | 90 | 320.04 | 1179.6 | 290.0 | 889.6 | 0.2058 | 4.859 | 1.0350 |
| 80.3 | 95 | 323.89 | 1180.7 | 294.0 | 886.7 | 0.2165 | 4.619 | 1.0362 |
| 85.3 | 100 | 327.58 | 1181.9 | 297.9 | 884.0 | 0.2271 | 4.403 | 1.0374 |
| 90.3 | 105 | 331.13 | 1182.9 | 301.6 | 881.3 | 0.2378 | 4.205 | 1.0385 |
| 95.3 | 110 | 334.56 | 1184.0 | 305.2 | 878.8 | 0.2484 | 4.026 | 1.0396 |
| 100.3 | 115 | 337.86 | 1185.0 | 308.7 | 876.3 | 0.2589 | 3.862 | 1.0406 |
| 105.3 | 120 | 341.05 | 1186.0 | 312.0 | 874.0 | 0.2695 | 3.711 | 1.0416 |
| 110.3 | 125 | 344.13 | 1186.9 | 315.2 | 871.7 | 0.2800 | 3.571 | 1.0426 |
| 115.3 | 130 | 347.12 | 1187.8 | 318.4 | 869.4 | 0.2904 | 3.444 | 1.0435 |
| 125.3 | 140 | 352.85 | 1189.5 | 324.4 | 865.1 | 0.3113 | 3.212 | 1.0453 |
| 135.3 | 150 | 358.26 | 1191.2 | 330.0 | 861.2 | 0.3321 | 3.011 | 1.0470 |
| 145.3 | 160 | 363.40 | 1192.8 | 335.4 | 857.4 | 0.3530 | 2.833 | 1.0486 |
| 155.3 | 170 | 368.29 | 1194.3 | 340.5 | 853.8 | 0.3737 | 2.676 | 1.0502 |
| 165.3 | 180 | 372.07 | 1195.7 | 345.4 | 850.3 | 0.3945 | 2.535 | 1.0517 |
| 175.3 | 190 | 377.44 | 1197.1 | 350.1 | 847.0 | 0.4153 | 2.408 | 1.0531 |
| 185.3 | 200 | 381.73 | 1198.4 | 354.6 | 843.8 | 0.4359 | 2.294 | 1.0545 |
| 210.3 | 225 | 391.79 | 1201.4 | 365.1 | 836.3 | 0.4876 | 2.051 | 1.0576 |
| 235.3 | 250 | 400.99 | 1204.2 | 374.7 | 829.5 | 0.5393 | 1.854 | 1.0605 |
| 260.3 | 275 | 409.50 | 1206.8 | 383.6 | 823.2 | 0.5913 | 1.691 | 1.0632 |
| 285.3 | 300 | 417.42 | 1209.3 | 391.9 | 817.4 | 0.644 | 1.553 | 1.0657 |
| 310.3 | 325 | 424.82 | 1211.5 | 399.6 | 811.9 | 0.696 | 1.437 | 1.0680 |
| 335.3 | 350 | 431.90 | 1213.7 | 406.9 | 806.8 | 0.728 | 1.337 | 1.0703 |
| 360.3 | 375 | 438.40 | 1215.7 | 414.2 | 801.5 | 0.800 | 1.250 | 1.0724 |
| 385.3 | 400 | 445.15 | 1217.7 | 421.4 | 796.3 | 0.853 | 1.172 | 1.0745 |
| 485.3 | 500 | 466.57 | 1224.2 | 444.3 | 779.9 | 1.065 | 0.939 | 1.0812 |

American Society of Mechanical Engineers have adopted as the commercial horse power, an evaporation of 30 pounds of water per hour, from a feed water temperature of 100° Fahr., into steam at 70 pounds gauge pressure; this is equivalent to 34½ pounds of water evaporated from a feed water temperature of 212° Fahr. into steam of the same temperature. To find the horse power of any boiler, therefore, we first must find the equivalent evaporation from and at 212° Fahr. by the following formula:

$$W = \frac{w(H - t + 32)}{966.1}$$

in which W = equivalent evaporation from and at 212° Fahr. in one hour.

$w$ = the actual number of pounds of water evaporated in one hour.

H = the total heat of steam above 32° Fahr. at the pressure of actual evaporation as found in the steam tables.

t = observed temperature of the feed water.

Divide the result obtained for W by 34½ to get the horse power.

As an illustration of the foregoing let us take the following example: A boiler generates 2200 pounds of steam per hour at a pressure of 120 pounds; the temperature of the feed water is 70 degrees. What is the horse power of the boiler?

By referring to the steam table, we find the total heat of steam at 120 pounds gauge pressure is 1188.6. Substituting the known figures for the letters in the formula, we have

$$W = \frac{2200(1188.6 - 70 + 32)}{966.1} = 2620 \text{ pounds.}$$

and the horse power will be

$$\frac{2620}{34.5} = 76$$

The 2620 pounds of water evaporated is the equivalent evaporation; that is, while the boiler actually evaporated 2200 pounds of water under the stated conditions, 2620 pounds would have been evaporated if the feed water had been 212 degrees Fahr. and the pressure had been that of the atmosphere or 14.7 pounds absolute instead of 70 degrees and 134.7 pounds absolute.

# STEAM ENGINEERING AT HALIFAX

At the last meeting of the Mining Society of Nova Scotia, Mr. Philip A. Freeman, chief engineer of the Halifax Electric Tramway Co., read a very interesting paper, entitled: "Steam Engineering," in which he described the engineering details of the Tramway Station and the operation and care of the plant. A part of his paper follows:

"In these days of keen competition it is absolutely necessary to take every precaution for reducing operating expenses, of which the coal pile represents a large percentage. At the Tramway plant it represents 62.5 per cent. at the buss-bar. The best of boilers will not take care of themselves, and will generate steam according to the manner in which they are treated. Shovelling coal into the furnace and keeping a sufficient supply of water in a boiler do not constitute the entire duties of a fireman. He must shovel coal and feed water to the boiler intelligently, and study the peculiarities of the steaming properties of his boilers and coal. I might add that no two boilers of the same make, with exactly the same handling, will give the same results.

"The proper maintenance of boilers demands that they should be shut down and examined inside and out thoroughly at least every nine weeks. At the Tram Co. we shut down every five weeks. The boiler should be thoroughly blown out and cleaned, even if solvents are to be used for the prevention of scale. In our plant we use the following method for preventing scale and for cleaning the boilers: The feed is supplied to the boilers through the 6" city water mains to the induction heater, then to the Cochrane open heater. This has already been described. When the boiler is taken off the line for cleaning and general overhauling, we pump it full of water in which about 20 lbs. of sal-soda have been dissolved, while it is still under pressure and the boiler stop valve closed. It is then allowed to remain 48 hours, when, by this time, the steam pressure has fallen. The blow-off is opened and the boiler emptied. It would seem at first that this would be sufficient to thoroughly clean the boiler, but it is not so. If the feed water valve is slightly opened and the water allowed to flow slowly through the boiler, it will then be thoroughly cleaned, as this slow filtration through the boiler seems to bring with it all the dirt, scale, etc., which was not carried away by blowing down. Also particular care should be taken that the feed valves of the other boilers are closed during the time we are filling the boiler with the sal-soda solution. Otherwise brass engine fittings, etc., will be seriously affected.

"Safety valves are the most delicate part of a boiler and demand constant care and watching, if we wish them to work fairly accurately. My experience with spring safety valves has led me to adopt the rule that all our safety valves shall be partially lifted from off their seats, once at least, every 24 hours. If this is not done, I find that a so-called skin forms on spring and seat, and if the valve is not lifted oftener than once a week, it will take considerably more pressure to lift it than for which it was originally set. Another very serious trouble with safety valves, which often occurs, is the loosening of the check nut, and if this is not attended to immediately upon the indication of such trouble, the steam pressure will drop and all steam escape into the atmosphere, shutting down the plant. Although it, at first, appears difficult to the engineer or fireman to tighten the nut and set the valve properly, nevertheless, if he understands his type of valve thoroughly, he can accomplish it with his monkey wrench, hammer and chisel, in a very short space of time, with perfect safety to himself and plant. If the valve should commence to blow off and steam pressure drop more than 5 lbs., or if the steam pressure should at any time drop more than proper on account of the safety valve blowing off, the engineer or fireman should at once assume that the valve is out of order, and must be attended to immediately. If check nut is loose, it can be remedied by turning the valve spindle to the right until the steam stops escaping. Then the cap may be removed and the check nut tightened without further difficulty. The boiler pressure should be increased to the same point at which the valve blew off and beyond in order to make certain that the valve will blow off at the proper pressure. This point can be easily obtained by slightly turning the valve in the proper direction.

"The above method of handling the safety valve is that

commonly used in ordinary practice, but for close regulation the cushion seat should also be raised or lowered according to the range within which it is desired to have the safety valve act. Under no conditions should the safety valve spindle or any of its parts be struck or hammered in order to make it close, as this is a very dangerous practice and is liable to cause more or less serious explosions. This latter precaution of mine may seem to be hardly necessary, yet, in my own experience, I have seen an engineer strike down on the spindle with a piece of 6 x 6 wood with the idea of causing the valve to close. Although at this time of which I speak no serious results occurred, it might have caused great danger the very next time it was tried.

"My experience has led me to believe that boiler explosions are caused by careless and unintelligent attention to the supply of water and not at all times through inherent defects in the boiler. The gauge cocks should be tried regularly in order to detect any false indications of water in the glass. False indication of water is not by any means an uncommon occurrence. The sudden breaking of a gauge glass causes the valves of the column to be closed, and on replacing the glass, the bottom valve is opened and the upper one forgotten. The glass, under such conditions, will show false water, as the water will remain in the glass until the boiler is emptied, held in position by the vacuum in the top of glass. This very case has occurred in our own plant, but any dangerous results were averted by prompt action. In connection with this I recall an answer given by a chief engineer in the West End Power House, Boston, to the Board of Examiners. He was asked what he would do if, on entering a boiler room, he discovered no indication of water in his boiler. He said he would make sure the water was shut off, close all drafts and open his furnace door. On being asked what he would do next, he replied that he would leave the building and watch it from a safe distance.

"Pumps are usually given the least care, worked the hardest of the equipment, and at the same time play the most important part in a station. They should be given the same careful attention as the steam engine. We make it a practice to completely overhaul our pumps once a week, in order to detect any faults that may exist or are liable to occur. Special care should be paid to the water plunger and valves. Valves should be used which are made to withstand the temperature of the water which passes through them. Disregard of this may cause serious trouble. In our plant we use brass valves in feed water pump. We use jet condensers, which give an increased economy of 20 per cent. Surface condensers should not be used if possible, on account of the deteriorating effect of the oil upon the tubes of the boilers. And if the water is not to be used again in the boilers, then there is no gain, but a loss in installing surface condensers, on account of increased first cost and increased cost in running. Heaters and condensers demand the same careful attention as pumps.

"The selection of an engine demands the same careful consideration as boilers. Whether high or low pressure; single or compound; high or low speed; steam jacketed, etc.; for heavy and variable loads, the compound engine is generally accepted. Large, low-speed, compound engines with wide expansion, are generally accepted as more efficient than single-cylinder engines. This is clearly shown by the results of tests on the compound engine. When this engine was run as a single engine it used 24 lbs. steam per indicated horse power, and when run as a compound engine with the same load steam pressure, and under the same general conditions, it used only 20 lbs. of steam per horse power, thus demonstrating that the compound engine was 30 per cent. more efficient than the single engine. Especially are compound engines more efficient with high steam pressures.

"Engines for street railroad work, and other work imposing sudden changes of load and unusually heavy strains, should be built with heavy forged cranks, and wheels of about double the usual weight, and with all parts in such proportions as will give perfect work under the most trying conditions. Governors for this work must be especially good, and must respond to sudden changes of load, and continue to regulate closely under all circumstances. The variable cut-off on low-pressure cylinder is also a strong point in such engines for this work, as it ensures quick work, quick regulation, and high economy. Under variable loads, the regulation of our Corliss engines is within 3 per cent., giving the greatest satisfaction, and up to the present time three of this type of engine have been in constant use on our total output, railroading and lighting since September, 1902, when our first Corliss unit started. November, December, January and February we have to run our three engines every evening except Sunday. Each engine runs 30 hours alternate, and the day load varies from ¼ load to 50 per cent. overload on account of the variable railroad load.

"An engine should be indicated every three months on account of the wear and tear of the parts, and the variation in the valve rod connections. In our old plant our engines were first set by hand, and then by the use of the indicator, a saving of 19 per cent. was shown.

"On taking charge of our old plant, September, 1895, the boilers were carrying nearly their capacity. By indicating the engines and setting valves properly we were able to increase our engine load 50 per cent., and only increased our boiler load 10 per cent. All this simply goes to show that the indicator should be used freely and intelligently in order to effect the greatest economy.

"The profitable use of steam jackets is a much-discussed question, and many engineers disagree. My experience with nine 1000 horse power engines, steam cylinder and head jacketed engines, has led me to doubt the advisability of using the steam jacket on the cylinder barrel. I advise jacketing the cylinder heads. In my opinion, the extra cost of maintaining the extra steam piping and the liability of damage to the cylinders more than counterbalance the saving obtained by steam jacketing the barrel of cylinder. If an engine cylinder has cooled down, the greatest care must be taken in re-heating the cylinder through the use of the steam jacket, or else a cracked cylinder will result, on account of the unequal expansion. Such an accident has occurred under my own observation, and it has not made me very enthusiastic to use steam jackets on barrel of cylinders. But I strongly advise steam jacketing the cylinder heads."

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In the parallel or multiple operation of alternators there are three conditions which need special consideration: frequency, phase and voltage. It is necessary that the generators be similar in these respects to insure their working together properly when connected in parallel.

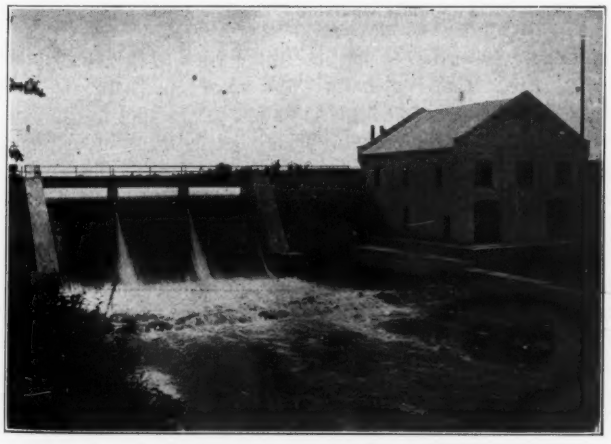
# Hydro-Electric Development of the Apple River, Wisconsin

The accompanying illustrations show the details of construction of the Somerset and Riverdale plants of the Apple River Power Company, Wisconsin, and the electrical equipment of these power stations. A high-tension transmission pole line has been erected from Somerset, and electric energy is conducted a distance of eight miles, for light and power purposes, to Richmond.

There are more than a score of lakes in Polk County, Wisconsin, which supply water to the Apple River as it flows through that county and through a portion of St. Croix County to Stillwater, Minn., where it empties into the St. Croix River. It is stated that the flow of water of this river is very steady and regular, seldom falling below 22 million cubic feet per minute.

The Somerset power station is supplied with water from a dam originally of wooden construction, but now re-inforced with concrete, the available head being about 16½ feet. There is a 48-foot spillway across the dam, and it is provided with a five-foot circular iron gate with screw and hoisting apparatus. This dam is 200 feet wide and has two flumes, each of which measures 36 feet in length, 10 feet in width, and 12 feet in depth.

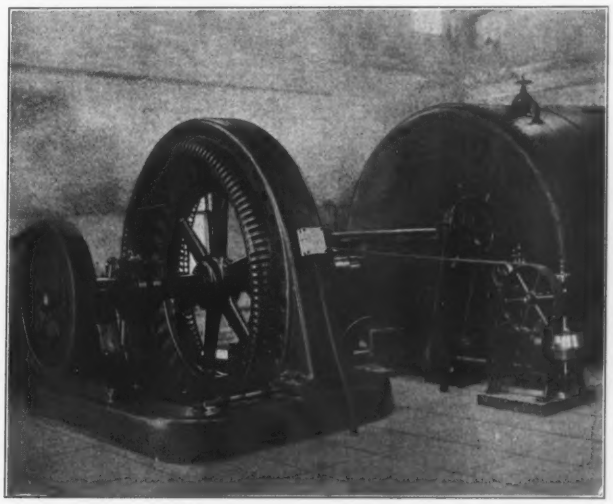
There are installed in one of the flumes a pair of 42-inch American turbines of 400 horse power output, constructed by the Dayton Globe and Iron Works. A 250 kilowatt 3-phase generator, constructed by the National Electric Co., is belted to the turbines, the pressure being 2300 volts, the frequency 60 cycles per second and the speed 450 revolutions. In the second flume a pair of 42-inch McCormick turbines are installed of 500 horse power output. A large pulley with a face of 40 inches, and a diameter of 129 inches is fixed to this turbine shaft and arranged to drive by belt transmission another 250 kilowatt National alternator of the 3-phase type above



**Riverdale Dam and Power Station.**

mentioned. The exciters for each of these alternators are mounted on the extended shaft of the turbine and generator, outside of the main bearing. The turbines have their speed regulated by Woodward governors, which are said to give excellent regulation, the speed being held practically constant.

The switchboard in this station includes two generator panels, with the usual switches, instrument transformers, ammeters and voltmeters. The switchboard equipment was installed by the Westinghouse Co. and includes a synchroscope utilized in synchronizing the machines. In addition to the two generator panels there is another panel on the main switchboard containing the necessary instruments for a Tirrill



**Interior of Generator Room, Riverdale, Wis.**

Voltage regulator, which is provided for additional regulation of the plant, this regulator being used to parallel the two exciters. There is also on this panel a 600 kilowatt 3-phase wattmeter which records the total output of the power station.

This power station is 55 feet in length and 35 feet wide, with two stories and a basement, being heated with hot water and lighted by a small transformer at the switchboard. There is a small 2 horse power motor provided, directly coupled to a triplex pump of the Stillwell-Bierce type which is used for pumping water for the circulation through the step-up transformer.

The transformer house is located 50 feet from the power station and is 14 feet wide and 18 feet long, with a total height of 12 feet inside measurements. It is provided with a concrete floor and in it are installed three 200 kilowatt step-up transformers of the oil-insulated water-cooled type. These step-up transformers raise the pressure from 2300 volts to 15,000 volts, and have delta connections. The current from this station is now transmitted to Stillwater, Minn., a distance of ten miles, at a pressure of 15,000 volts and it is utilized for lighting and power distribution in that city, being distributed by the Stillwater Gas and Electric Light Co.

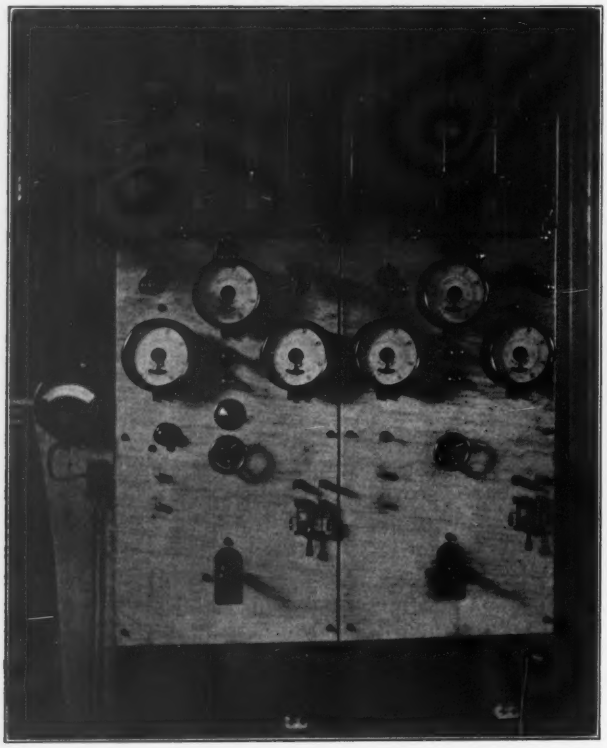
The dam of the Riverdale power plant, recently constructed by the Apple River Power Co., is 500 feet wide, of which 160 feet are concrete, the remainder being earth embankment with concrete core. The foundations were carried 15 feet below the bed of the river and piling was used of railroad iron, the entire width of the concrete portion about of the iron being embedded in the concrete.

The total weight of the dam is said to be 28,000,000 lbs., the base of the spillway being 37 feet and the base of the dam 55

feet wide, up and down stream. The spillway is 20 feet above the bed of the river and 56 feet wide, the wasteway being 22 feet wide, provided with 3 four-foot circular iron gates with the necessary hoisting apparatus. It is stated that with the hoisting device provided one man can raise or lower these gates without difficulty with a head of 24 feet of water.

There is a forebay 40 feet wide, and at the east end of the dam is constructed the Riverdale power station, which is equipped with a pair of 500 horse power turbines of the McCormick type, in each of the two steel penstocks 11 feet in diameter, giving a total output of 1000 horse power. These turbines operate at a speed of 189 revolutions per minute.

From the forebay, the water is conducted by two steel flumes, 10 feet in diameter, to the penstocks above-mentioned, and



Switchboard in Somerset Station.

each flume is provided with a head gate 11 feet in diameter. To each of the turbine shafts is directly coupled a National Alternator of 250 kilowatts capacity, supplying a three-phase current of 2300 volts pressure and a frequency of 60 cycles per second. These three-phase machines supply current to three step-up transformers, which are located in the power house with the usual circuit breakers, lightning arresters and switchboard equipment. The current is raised in pressure to 15,000 volts and conducted over an overhead pole line a distance of 12½ miles, where it is used for light and power service.

The poles are from 25 to 45 feet in length and of Michigan cedar, with cross-arms 4 feet in length bolted through the poles and supported with cross-arm braces, ridge irons being used for carrying the insulators. The insulators are tested to 60,000 volts and are of the Locke brown porcelain type, placed in a triangle 40 inches on each side.

The conductors of this power transmission line are of aluminum strand, having the same conductivity as No. 4 copper conductor. The weight is about 48 per cent. of copper wire of the same conductivity and the difference is said to be of considerable importance in the cross-arm and pole construction.

As this transmission line crosses the Wisconsin Central Railway it was necessary to use underground cables of the high-tension type placed under the tracks before permission was granted by the Railway Company for right of way, no overhead construction being allowed. A pole line crossing has also been constructed by agreement with the Railway Company, but only to be used in case of emergency and trouble with the cable by damage from lightning or otherwise.

The high-tension line also passes over Lake St. Croix Bridge, which is 1800 feet long and has a pontoon drawbridge, which opens and closes to navigation, and therefore an armored submarine high-tension cable was necessary. This high-tension armored cable is 525 feet in length and is laid under the waters of the St. Croix Lake at the pontoon drawbridge above-

Transformer House at Somerset Station.

mentioned. In order to be absolutely sure of uninterrupted service, an overhead pole line was also constructed at this point using poles 80 feet high so as not to obstruct navigation. The pole line over the pontoon bridge is used continuously and the cable is provided for emergency service should storms damage the high-pole line.

The Power Company owns 12½ miles of right of way between Stillwater, Minn., and Riverdale, Wisconsin, and substations are located 200 feet from the bridge at Stillwater, also at Riverdale and Somerset.

There are three step-down transformers at Stillwater Substation, each having a capacity of 600 kilowatts, the pressure being reduced to 1100 volts from 15,000 volts. These stationary transformers are also of the oil-insulated, water-cooled type, similar to those at Somerset and Riverdale.

A contract has been entered into between the Stillwater Gas and Electric Light Co., of Minnesota, and the Apple River Power Company, in which the latter Company agrees to sell all the electrical energy generated by it for the next 25 years to the former Company at the rate of $25 per horse power per year, for 24 hour service.

# PRACTICAL EXPERIENCES WITH STEAM TURBINES

At the recent meeting of the Iowa Electrical Association, held at Des Moines, Iowa, Mr. C. E. Stanton, Chief Engineer of the Union Electric Company, at Dubuque, Iowa, presented a paper entitled: "Some Practical Experiences with Steam Turbines." The paper is based upon Mr. Stanton's everyday, practical experience, as encountered in the erection and operation of Curtis four-stage, 500 kilowatt turbines and while the first turbine installed has been running but one year, the information presented is valuable, as it is just the thing that the practical man has been awaiting for some time.

The paper first takes up the step-bearing pumps, bafflers, strainers, etc., connected with Curtis turbines, after which the step-bearing, the steady bearing, the turbine pilot and main nozzle valves, middle and top bearings, and lubrication as taken up, as follows:

"All step-bearing water passes first through a "Jewel" water filter, thence through the pumps to the strainer which is contained in the 'baffler casting'—thence through the baffler direct to the step-bearing. By its passage through the baffler the pressure of the water is reduced, so that (in our case) the actual step-bearing pressure is from 180 lbs. to 200 lbs. per sq. in. All shock or pulsation of the step-bearing pumps is also eliminated by the baffler. As the step pumps and the service pump, which supplies the water used in the step-bearing pumps, are packed with a fibrous packing, we soon found we must keep a record of the safe life of this packing—as, if left in until it began to lose its elasticity and get soft, small particles and strings of packing would find their way into the strainers, and would soon plug them, thereby cutting off the water supply to the step. We find that on the step pumps, which pump against a pressure of 400 lbs. per sq. in., the safe life of the packing is sixty days. On the service pump, against 50-lbs. pressure, the safe life of the packing is four months to five months, depending on the condition of the river—whether muddy or not. We find that if dirt or pieces of packing do get into the step-bearing pipe system, it is uncertain when they will find their way into the strainers—it may be hours, days or weeks. This uncertainty is far from pleasant, because if there is enough loose packing in the system it can at any time plug the strainers, thus cutting off the water supply to the step-bearing. With us, all strainers are taken out and cleaned every twenty-four hours.

"The hydraulic accumulator, which is connected into and forms a part of the step-bearing piping system, and which acts as a reserve in case of the temporary stoppage of the step-bearing pumps, is tested every twenty-four hours. To test the accumulator, the throttle on the step-bearing pump is closed slightly, as we run the step pumps just fast enough to keep the accumulator up. This slight closing of the pump throttle allows the accumulator to drop slowly. We lower it four or five feet every day. As there are always one or more turbines in operation, and as we carry just pressure enough on our step-bearing pumps (400 lbs.) to keep the accumulator raised, if it was not for the test each day, it would always be up and would finally rust fast and would not come down, even if all pressure was removed from the pipe system which holds it up—thus defeating the object for which the accumulator is used. We know by experience that the accumulator will stick, if not tested often. The ram or piston of the accumulator is 9 ins. in diameter, and the bored part of the cylinder, which acts as a guide to steady the accumulator when raised, is about 36 ins. in length. As this bored part is a close working fit on the ram and the water is always in contact with it, the nicest kind of a rust joint will finally form between the ram and the bored hole around it.

"One other precaution, which is usually taken in connection with accumulators for this work, is some kind of signal, usually a steam whistle, which will blow if the accumulator starts to come down. Something of this kind is necessary, as without it, if the step pumps should slow down, and there are many reasons why they should do so, the step pressure might get so low as to be dangerous and injure the step.

"As the step-bearing, with its very thin film of water, under pressure has to support the weight of all the revolving parts of the turbine, wheels, shaft, field, etc., it is a very important part, and cannot be examined too closely while being assembled. Under the bottom half of the step-bearing is the adjusting screw; this screw is vertical and in exact alignment with the turbine-shaft centre. The end of this screw, on which the step-bearing and all the revolving parts of the turbine are carried, must be exactly square with the axis of the screw—a burr or dirt here means trouble, as it will throw the step out of its true alignment. This is also true in regard to the top of the upper step plate and the bottom of the turbine shaft, which rests in a socket or recess in the top of this plate. In the bottom of the turbine shaft are drilled two guides or dowel-pin holes. A key way is also cut across the bottom of the shaft, the guide pins and key are made fast in the top of the upper step-bearing plate, and are an easy fit in the shaft—if all surfaces are clean and all burrs, scratches, etc., removed.

"If through any cause the step plate should bind, either from dirt, abrasions, or a bad fit, and it should be forced up in place, the chances are that it would not be square with the shaft. The turbine would then have a tendency to vibrate, and might not run right until this fault was corrected. The bottom step-bearing plate should be an easy fit in the casting which holds it and the adjusting screws in place; it should drop of its own weight into its socket or recess and should not bind or have to be forced to its set. Both step plates should be of exactly the same diameter and should line perfectly. The recess in the plates, from which the step-bearing water is forced out between the faces of these plates, should also be of exactly the same diameter and depth. The edges of the recess should also line perfectly, as if they were not in line, a fin might form around one side of the recess, which would cause an unequaled flow of water from the step and have a tendency to cause vibration.

"If for any reason it is desired to grind the step-bearing in place, it can be done very easily, and without any trouble whatever by gradually closing the stop valve between the step-bearing main pressure pipe and the step-bearing. By listening at the step-bearing and watching the step-bearing

gauge while very slowly closing the stop valve, any degree of pressure can be had between the two bearing faces of the step. It should be borne in mind that the greater the speed of the turbine while grinding the step, the faster the faces will grind, and the more damage would be done if the stop valve was closed enough to let the steps together hard.

"Directly above the step-bearing is the steady or guide bearing. This is a bronze shell, flanged on one end, lined with Babbitt metal, and bored about .006 in. larger than the shaft. It is held in place by stud bolts through its flange; these studs are screwed into the bottom of the turbine base. The outside of this sleeve is tapered and fits in a corresponding tapered hole in the base of the turbine. Before this bearing sleeve is put in place, it should be thoroughly cleaned and examined for any rough spots. If it should not seat perfectly all around when in place, it will work loose; screwing up on the nuts will not hold it. We have had two or three loose steady bearings, and in each case the trouble was found to be due to dirt, bruises or metal chips, which would not allow the bearing to seat properly.

"Before leaving the subject of bearings, I want to say that the first turbine started in our plant, and which has done all of its share of the work since (about one year), has the original step-bearing and guide sleeve still in place, and apparently as good as ever.

"There are eight main nozzle valves, each with its individual pilot valve, which is electrically controlled. The pilot valves control the action of the main-nozzle valves. On any load within the rated capacity of the turbine, running condensing, five valves are all that will open, leaving three valves which might not open for days at a time. If these valves are left alone they will corrode and stick, and if a heavy overload should come on might not open at all—or if they did open they might stick open. In this case, if a short circuit should open the breakers, the turbines would run away, causing the safeties to act and shutting off the steam supply to the turbines. This would cause considerable more delay in getting current back on the line again. If the main valves are packed too tight, or if the pilot valves leak, the main valves may stick. To obviate these troubles all valves are opened and closed several times each day when starting turbines. As the pilot valves are electrically operated, and as they govern the action of the main-nozzle valves, all that is necessary is to make or break the electrical contact for each valve, which, if kept in proper condition, will open and close promptly.

"The close regulation of the turbines was a surprise to some of us who had spent many years in charge of belted and direct-connected engines and generators. It was the original intention to use separate turbines and bus-bars for the commercial lights, but this has not been found necessary. Everything we have—railway, power and lighting—is on one set of bus-bars. We have no trouble with the regulation of lights or turbines.

"A suitable packing for the main-nozzle valves was at first hard to find. We first used a kind of string metallic packing which has proved successful on lower steam pressures, but found it would melt here, as 190 lbs. of steam and 150 degs. of superheat were too much for it. We then tried another kind of metallic packing, guaranteed to stand any degree of superheat. This seemed to be made up of small metal chips and graphite, and was supposed to form a well lubricated metallic ring which would last for months. In use, however, the chips of metal would get under the pilot and main valves holding them open. All valves had finally to be taken out and cleaned. In cleaning the stuffing boxes all that was found of the packing was a lot of loose metal chips. We now use the best asbestos ring packing we can get, and pack the valves more often than we expected to with the metallic packing.

"The middle bearing is made in halves of cast-iron, Babbitted and bored out about .01 in. larger than the shaft. Extra large oil grooves are cut in both middle and top bearings—they run in a bath of oil, and with a circulation of oil through the bearings more than would be possible with any other type of bearing with which I am familiar. The top bearing is a cast-iron shell flanged on one end, Babbitted and bored about .01 in. larger than the shaft; it is clamped in place by bolts through the flange, if it is a solid bearing. We have used both solid and spring bearings for the top and middle bearings. At first all bearings were solid; at present both top and middle bearings are of the spring type. On two turbines the springs have been renewed several times; on one once or twice; on the fourth, or rather the first one supplied with spring bearings, the first bearings put in are still in use—it is about six months since these bearings were first put in.

"Gravity oil feed is used on all turbines, and the bearings are so constructed that there can always be a strong circulation of oil through them.

"One trouble we had can be best explained by first giving the layout of our gravity oiling system. From the turbines the oil flows by gravity to the oil-cooling and separating tank, then through the oil filter to the suction tank, from which the oil pumps take the oil and pump it into the gravity-oil-feed tank, which is perhaps 25 ft. above the turbines. From this tank the oil flows to the turbines, then to the cooling tank, and over its same route through the filter, etc. We have a valve so placed that when closed it cuts the oil off from the gravity-oil tank and puts the full force of the oil pumps on the oil-feed line. This valve proved to be our salvation several times before we learned where our trouble was. With three or four turbines on, the oil would suddenly stop running on the turbines. The only thing left to do was to partially close the valve on the delivery pipe to the gravity-oil-supply tank, putting the oil pump directly on the oil-pipe system, when, of course, the oil had to come if the pumps were in order. It was finally decided that air must trap in the gravity-oil tank, and getting into the oil-feeder-pipe line interfere with the flow of oil. This would cause an intermittent flow at certain times, of which we had no means of knowing until we found our supply of oil shut off. That this was right has since been proven by the remedy, which was to vent the top of the tank. We used a ½-in. pipe 4 ft. or 5 ft. long, with the top bent over in the form of a goose neck.

"One point in regard to the step-bearing pumps which was overlooked by me, and should have been mentioned in its proper place, is concerning the water valves. After nine months' service it was noticed that the pumps were running much faster than at first, to do the same amount of work. An examination showed that the water valves and seats were cut quite badly, and nearly all the way around with shallow grooves, mostly, although some spots looked, as far as their shape was concerned, more like corrosion than anything else. We made a tool to true up the seats in place and faced the

valves off in a lathe; with a slight grinding with emery dust we had them in good condition again. It was thought that as these valves should open and close positively with each stroke of the pump, they should not cut so quickly, or as badly as they did. Close examination showed that a close hard scale had formed on all valves and seats, and this seemed to hold the valves slightly away from their seats. This wire drawing of the water (if it can be so called) was thought to be the principal cause of the cut valves. We now clean them free from this scale each week."

# CREEPING OF BELTS

At the recent meeting of the New England Cotton Manufacturers' Association, held in Boston, Mass., on April 25th-26th, Mr. W. W. Bird read an interesting paper on "Belt Creep," a part of which follows:

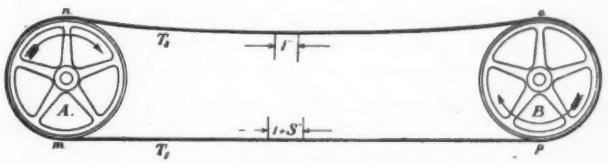
"The relative speeds of two belt-connected pulleys is an everyday problem in power transmission. The solution of the problem is very simple if 'somewhere near right' is good enough. If a four-foot pulley, making 100 revolutions per minute, drives a one-foot pulley, then the smaller pulley will make 400 revolutions per minute according to the rule that the ratio of the speeds is inversely as the ratio of the diameters. To be more accurate, it is necessary to consider the thickness of the belt and the crown of the pulleys, assuming that the correction for this increases the diameter of each pulley ⅜ of an inch, then the smaller one would make 390.9 revolutions per minute, or a difference of more than two per cent. This correction is generally made by taking the diameter of the pulley on the crown, for the pitch diameter, with no allowance for the thickness of the belt. The correction, however, to be more accurate, should be made by taking for the pitch-radius of the pulley, the distance from the centre to the middle of the belt at the mean diameter of the pulley. That is, average the diameter of the pulley at the crown with the diameter at the edge of the belt and add the thickness of the belt; this gives the pitch diameter. And the speeds of any two connected pulleys are inversely proportional to the pitch diameters.

"There is, however, another factor to be considered if it is necessary to know just how fast the one-foot pulley is to run, and this brings us to the subject of the paper, 'Belt Creep.'

"In the diagram, let $A$ be the driver and $B$ the driven pulley. Let $T_1$ be the belt tension on the tight side and $T_2$ the tension on the slack side. Let the belt and pulleys be running in the direction indicated. Then, one inch of belt from the slack side goes on to the pulley $B$ at $o$. As it nears the point $p$ it begins to feel the effect of the increased tension and stretches to $(1 + S)$ inches in length as it leaves the pulley. It now travels from $p$ to $m$ and goes upon pulley $A$ in this stretched condition. As it nears the point $n$, the tension decreases and the section contracts to the original inch as it leaves the pulley $A$ and completes its cycle. The difference between the tensions $T_1$ and $T_2$ is the effective tension T and this varies with the load. When the load is light, the belt stretches near the point $p$. If the load is heavy, the stretching extends over a greater arc and if it reaches $o$, the belt slips on the pulley; this may also take place if the belt is loose, even with a light load.

"As the belt stretches on the pulley $B$, it creeps ahead, the amount varying with the load and the elasticity of the belt. It can be readily seen that the pulley $A$ must be running faster than $B$ to take up this stretch. On the pulley $A$ the belt creeps back relative to the pulley at $n$, so that the belt does not come off as fast as it goes on.

"Under ordinary conditions the loss due to creep will not exceed one per cent. and would only amount to about two per cent. with a fairly elastic belt at slow speed. Allowing one per cent. for belt creep, the speed of the one-foot pulley will be 387 revolutions per minute.




Illustrating Belt Creep.

"Another interesting fact with regard to belts has been shown by experiments conducted at the Worcester Polytechnic Institute and this is that the pressure on the shaft bearings increases with the load. The old theory was that the sum of the tensions remained constant. That is, as the load came on, the tension on the slack side increased—the sum remaining constant and depending upon the original tightness of the belt when put on.

"Experiments have shown that as the load comes on, the belt on the tight side stretches more than the slack side contracts, the result being that the sum of the tensions increases, thus bringing a greater pressure on the bearings. This is probably due to the variation in the modulus of elasticity as effected by the element of time. If the belt was non-elastic, as on a chain drive, the pressure would increase directly as the load, while if the belt were perfectly elastic and could stretch and contract instantly, the pressure would remain constant."

Wrought-iron expands 1-150,000th of its length for each degree Fahrenheit. To find the expansion of a line of pipe, multiply its length in inches by the number of degrees of temperature to which it is raised and divide the product by 150,000; the result will be the required expansion in inches.

To find the length of a cross belt, square the diameter of the large pulley and the distance between centres, add together and extract the square root of the sum; subtract from this the distance between centres and multiply the remainder by two and add the distance around outside of both pulleys. The result will be the length of cross belt.

Doubling the diameter of a pipe increases its capacity four times.

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**Requirements for a Clear Chimney Top.**

When coal is burned in a boiler furnace, every atom of carbon in the coal must combine with two atoms of oxygen taken from the air in order to secure the maximum efficiency. A pound of carbon burned under these conditions will give a heating value of 14,500 heat units and the resultant gas is called carbon dioxide, designated by the symbol $CO_2$. When the boiler furnace is not supplied with sufficient oxygen, some of the carbon in the coal will either remain unburnt or else it will form the gas known as carbon monoxide (CO). When a pound of carbon is burnt under these conditions, only 4400 heat units are given out, so that a loss of 10,000 heat units per pound of carbon burnt is the result.

In general practice, however, this latter condition does not prevail, as there is generally a very liberal supply of air to the boiler furnace, but this condition is also wasteful, because any more air than is necessary to support complete combustion will absorb heat and will carry that heat out of the chimney, instead of allowing the boiler-heating surfaces to absorb it.

A third condition also ofttimes prevails, and that is, the superabundance of air with an incomplete combustion of the carbon. This is the commonest condition found in practice and is indicated by the presence of carbon monoxide and a large surplus of oxygen in the flue gases. There must always be more air used than is actually needed, owing to difficulty of intimately mixing the different atoms of carbon and oxygen. For instance, while it would only require about 150 cubic feet of air to burn one pound of carbon completely, in practice from 225 to 300 cubic feet are used. This excess of air dilutes the fire box and results in loss.

Of the two kinds of coal in use, bituminous coal is by far the hardest to burn properly although on account of its smokelessness, many anthracite fires are being burned at a loss and large amounts of excess air are being used unconsciously. The only way to detect the loss in the latter case is to make a flue gas analysis and take the temperature of the escaping gases. With this information at hand, the supply of air can be regulated to obtain the maximum efficiency of the furnace.

When burning bituminous coal, the appearance of the top of the chimney will often indicate the degree of proper combustion, although the amount of heat lost by the carbon in the smoke is often over-estimated. It is, however, of sufficient importance to always prevent it and in large cities it is now becoming imperative that bituminous coal be burnt without smoke. In places where the smoke ordinance is in force, it has almost become an axiom that those places which most strongly object to putting in smoke prevention devices are usually the ones which are its strongest advocates afterwards, not so much on account of the abatement of the smoke nuisance but principally on account of the fact that smokelessness means more perfect conditions and greater economy in the furnace.

There are a number of requirements necessary to maintain a clear chimney top and these are: First, the carbon shall be burned to carbon dioxide; secondly, there must be sufficient air to burn any smoke that may be formed; thirdly, any smoke that is formed must be burned before it touches the water surfaces of the boiler; fourthly, if any smoke is going to form, it should be allowed to form before reaching the boiler tubes; fifthly, the air, which burns the smoke in its evolution of

forming, should be so heated by the fire as to burn it quickly.

The regulation of the air to do this is a difficult problem. When fresh fuel is added, smoke is evolved in large quantities and an increase in the supply of air is necessary to burn it; but the air being cold, combustion is checked to a certain extent and in addition there are three heat absorptions: The heat required to liberate the smoke, the heat required to supply the gas as it expands, and the heat required to ignite the smoke. As the formation of smoke ceases, less air is required and if the fire is very hot and the charge small, the fire door need only be left open a short time. An intensely hot fire and a short, quick combustion are two important requirements when burning bituminous coal. The oftener the coal is added, the smaller and more uniform will the smoke be, but this requires almost constant attention.

In all mechanical stokers this principle is taken advantage of as well as the fact that radiant heat from above is the most effective way to prevent smoke from forming. Firebrick arches are found to give good results when burning bituminous coal, as they act like a fly-wheel, tending to give out heat when the smoke is forming, thus burning it, and tending to absorb heat between the intervals of firing when the fire is hottest. Perfect combustion in the presence of water surfaces of the boiler, which are abstracting heat, cannot be had, and to get in combustion must take place in the presence of firebrick or some other non-conducting substance before the completed gases of combustion strikes the boiler-heating surface.

To maintain a clear chimney top, the requirements are the same, whether hand firing or mechanical stokers are used, but since a stoker works with mathematical precision and is tireless, they are generally found in plants where the boilers must be forced and where the atmosphere must be untainted.

**Weathering of Coal.**

When a coal strike is expected, both the coal Companies and the large consumers of coal, store immense piles of coal for use during the period when it is expected the coal mines will not be in operation. The result of this is, the decrease of the heating value of the coal, even when the coal piles are covered with sheds to protect them from the rain.

Some recent experiments in the storage of coal made by the British Navy illustrate the fact that when coal is stored in the open air there is a gradual decrease in calorific value of the stored coal. These same experiments also included the storage of coal under water and it was found that owing to the weathering and escape of gases in the open air, the coal that was stored under the water suffered less in deterioration than that which was stored in the open air. Every few months coal from each storage pile was accurately tested for its heating qualities and the above conclusions were arrived at.

The effect of the weathering of the coal is to increase its weight and to diminish the quantity of carbon and free hydrogen, which are most useful for burning, and to increase the oxygen and hydrogen of the coal in the form in which it is not available for economical burning. Therefore, there is a loss in the calorific value. It is said that bituminous coals suffer more from weathering than anthracite coal because the effect of the weather is to reduce its coking power by changing its chemical composition.

When coal is kept under water, the oxidation, which takes place in air, does not occur. The excess of pyrites in the coal does not have the same chance to become rapidly oxidized. It is this oxidization and consequent disintegration that cause the development of heat in the coal pile and when large coal piles are stored, spontaneous combustion is often the result.

Tests which have been made to find the reduction of calorific value due to weathering have shown a loss of over 2 per cent. in one month of the original heating value of the coal. Of course, it is impossible to tell in advance just how much any coal will deteriorate, as it depends upon the chemical composition of the coal, the temperature of the weather, and the manner in which it is stored, but all coal will deteriorate to some extent.

The important fact is, that while the calorific value of this stored coal has decreased, the consumer is made to pay the same price as for freshly mined coal. While in time of strikes, this matter fades into insignificance, owing to the importance of getting any kind of fuel to run the plant, yet at other times it might have a considerable effect upon the plant.

An engineer may be showing a certain economy for his plant, when suddenly the number of tons burnt per week will have jumped up considerably without apparently any cause. This will often be due to the quality of the coal. It may be that the vein from which the less economical coal is mined is not of good quality or it may be due to weathering. It is a well-known fact that many manufacturers of fuel-saving devices hesitate about running a test on weathered coal, even though the test is based upon the number of thermal units in the coal.

There has always been a popular supposition that coal does deteriorate when subjected to the weather, but unlike most popular supposttions, in this case, at least, it is founded on fact.

**Draft and Economizers.**

When an economizer is put in an old plant, the result is a decrease in the natural draft, which depends upon the decrease in the temperature of flue gases. It is estimated that if the temperature of the flue gases is reduced from 400 to 325 degrees by the economizer, there will be a reduction of draft of 15 per cent.; if the temperature is reduced from 500 degrees, there will be a reduction of draft of 25 per cent., and if the temperature is reduced from 600 degrees, a reduction of 35 per cent. of the draft will occur. A mechanical draft apparatus must therefore be used to get the same rate of combustion from the furnaces, and in the design of mechanical draft apparatus for economizers, it is usual to first find the draft necessary without an economizer and then increase this by 50 per cent. to get the draft necessary for the same combustion when an economizer is used.

**Induced Draft.**

When induced draft is used, the fan is placed beyond the boiler in the uptake and by its action a partial vacuum is maintained in the uptake, the flues and the furnace. The air enters the furnace because the pressure there is less than that of the atmosphere and the gases of combustion flow from the furnace to the fan and are then discharged into the atmosphere.

# LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

## A Boiler Feed Pipe Repair.

EDITOR THE PRACTICAL ENGINEER:

Some time ago, I was called upon to renew that part of the feed pipe which entered the head of the boiler. The boiler was of the horizontal tubular type, of about 4 feet in diameter, and was located in an office building and was used for heating and elevator service. The feed pipe was one-inch ordinary iron pipe and had for quite a while been leaking around the threads where it was screwed into the boiler head, and as this leak kept getting worse, it was decided to renew that part of the pipe. The boiler was therefore cut out of service (there being another of the same size to carry the load in the meantime) and after taking out the feed pipe—which, by the way, had become so thin from corrosion that it twisted off instead of screwing out, leaving a ring of pipe in the threaded hole in the head.

By carefully handling a round nosed chisel, such as is used for cutting oil grooves in the brasses, the ring of pipe was removed from the hole and I found that the internal surface of the head immediately surrounding the hole in which the feed pipe was screwed was unevenly and badly corroded. The head was originally $\frac{3}{8}$-inch thick but was reduced in some places close to the hole to about $\frac{3}{16}$-inch and thus at those places the feed pipe was held only by about three threads of the screwed part. While the pipe had held before, it was not thought safe to depend entirely upon the new pipe just being screwed into the head, as was the old pipe.

First, the hole was cleaned out by running in a pipe tap. The new piece of pipe was threaded sufficiently far from the end to permit of a nut and washer being placed on it, one on each side of the head through which the pipe passed. Not being able to discover any lock nuts around the plant, we simply cut the hexagonal nuts off an old globe valve which was found and ran the pipe tap into them far enough to admit of them being screwed on the pipe.

Next we filed out two $1\frac{1}{8}$-inch iron washers to neatly fit over the threads of the pipe. Screwing one of the nuts on the pipe as far as it would go by hand and placing one of the washers next to it, the pipe was dipped into a thick red lead and boiled linseed paint. It was then screwed into the boiler head and far enough beyond to allow for the other washer and nut. A wrapping of lamp-wick was next wound around the threads of the pipe between the boiler head and the washers referred to, on each side, and the nuts and washers set up tightly and equally as could possibly be judged.

The surfaces of the nuts, washers, exposed parts of the pipe, and the surrounding portions of the plate both inside and outside were then covered with a coating of the red lead paint and allowed to dry before the boiler hand-hole was put in place and the boiler filled with water. The new piece of pipe was connected with that part of the old feed pipe which had not been disturbed by the introduction of a brass union located just outside of the smoke box doors in front of the boiler.

Upon testing the job with cold water under pressure and later under working conditions, there was not the least appearance of leakage nor has there been any since.

Scranton, Pa. CHAS. J. MASON.

## Improper Examination Questions.

EDITOR THE PRACTICAL ENGINEER:

I have read with much interest the questions published by J. R. in the May issue and he is entirely right in his contention. On page 27 of the same issue the editor answers the questions asked by H. W. and also places them in the class of theoretical questions unsuitable to be asked a practical engineer.

I have watched this thing of examination questions for several months and it is enough to make a man blue in the face to read some of the things asked engineers. When one is through reading the questions, nine cases out of ten he is justified in believing that the examiner is a wilful lawbreaker. If the reputation of the examiners as citizens makes it impossible to regard them as law breakers, one must be forced to the conclusion that they are too ignorant of the matters at issue to be on an examining board. If it is conceded that the examination consists of catch questions, the examiners are placed in a category of men who should be outside of the pale of the engineering profession.

If a board should ask an engineer what he would do if the fireman went to sleep and let the boiler blow, it might be as foolish a question as some of those asked, but it would certainly be more practical. Why don't they ask a man how he would cool a hot bearing and keep things going while doing it. Or they might ask how to set up an indicator and take a set of diagrams and how to set the valves if the card shows bad steam distribution. Almost any thing would be better than such an ignorant dive into the theory of design as that made by the originators of the questions published by J. R. To answer these questions properly, several assumptions would have to be made and a designing engineer would have to get out his tables and handbooks and put in at least one good day's work at figuring. Taking up the questions and "considering an upright high-speed Corliss compound condensing 2000 horse power engine," it is impossible to give the economical boiler pressure unless the piston speed and high-pressure cylinder diameter are known. With the mere statement "high-speed" as the determinant, a man could not guess the pressure within 30 per cent. of the correct amount for any given speed. This applies with more force to the second question which asks for the initial, mean effective, and terminal pressures of each cylinder. Here the cutoff would also have to be guessed at, thus making another assumption.

As to the third question, it is sufficient to say that the cylinders might have any number of dimensions depending on the piston speed, which is asked for in the fourth question. The fifth and sixth questions treat of *theoretical* cards and are certainly not *practical* questions.

If these questions had been given to a designing engineer

to test his ingenuity in making assumptions and in choosing a set of conditions that would give a theoretical result for a hypothetical engine, one could praise the examining board. Since the questions were put to practical engineers seeking for licenses, the examiners must be condemned and they cannot be handled too severely.

These questions remind me of the following recently asked in a license examination: "What is the power developed by a duplex 8 and 10 by 12-inch pumping engine forcing 200 gallons of water 150 feet in one minute?" From this it would seem that the examiners thought that the suction head or lift, as the case might be, had nothing to do with the question or the data that should be given to the man who has the answering to do.

Chicago, Ill. E. S. H.

### Practical or Theoretical?

EDITOR THE PRACTICAL ENGINEER:

In the May issue, on page 22, J. R., of Fall River, Mass., has a letter in which he gives a list of questions which were asked of an applicant for a first-class engineer's license. He then adds that in his opinion the questions are theoretical, instead of practical. It seems to me that there is nothing in these questions, unless it be the last one, which is beyond the power of an engineer to understand and they are certainly practical.

The law of Massachusetts states that the holder of a first-class engineer's license may take full charge of and operate any steam plant in Massachusetts. An engineer who aspires to that position should certainly be qualified to answer all the questions given; not off-hand, of course, but after a reasonable consideration. The means of obtaining the knowledge required is within the reach of every ambitious engineer in Massachusetts and if he does not know how to obtain the answers to such questions as these, he ought to use all his spare time until he is able to do so. I know that a good understanding of mathematics is needed and also that many of our craft are very deficient along that line. But there are many things harder to understand than mathematics and the man with brain power enough to make him capable of handling a large steam plant successfully, certainly can train his brain to understand all the mathematical problems in the given questions.

The question may be asked: "Is it necessary for the successful engineer to understand these things?" Some men who cannot do so have risen and successfully filled good positions, but those same men, if they had a good education, self-obtained or otherwise, would no doubt have filled much better positions. I believe every engineer should be qualified to answer such questions before he is given a first-class license in this State and then the best men would soon be advanced to the most responsible and best paying positions and would be qualified to fill them.

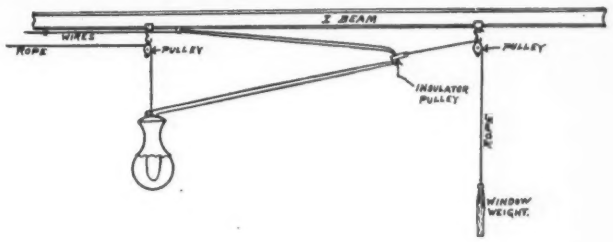
The great trouble with many engineers is that they get scared too easily. These things are not so frightful as they seem to be. Get after them with the same energy and determination as you would go after a hot crank-pin or a bucking condenser and you will soon find such problems losing their frightful aspect, and the information obtained will be the means of helping you to better and more lucrative positions.

Lawrence, Mass. S. J. S.

### Arc-Light Wire Swing.

EDITOR THE PRACTICAL ENGINEER:

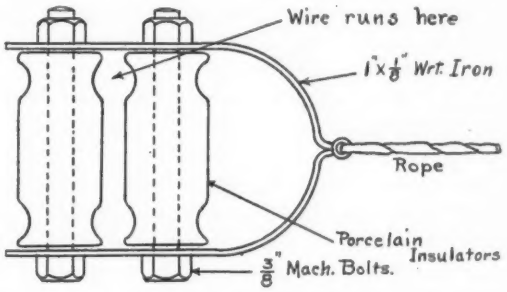
I send herewith a rough sketch of a device used in connection with the arc lights installed by me in a power plant at Anna, Southern Illinois.




Arc Light Wire Swing.

It was not possible to let the extra wire hang in a loop below the lamp, as is usually done, because there was a crane passing back and forth underneath; so I conceived the idea of the wire-swing or support, as shown.

When the lamp is lowered for trimming, the insulator pulley supporting the wires is pulled forward, as the loop of wire straightens out and the weight rises. When the lamp is being raised, the weight pulls the slack wires up out of the way. At first we weighted the swing with one 5 pound




Detail of Insulator Pulley.

window weight but found that that was not quite heavy enough to make the device work easily against the stiffness of No. 12 wire. When we hung two weights on, however, there was no more difficulty. The scheme has been working successfully and may prove of interest to other engineers.

Port Huron, Mich. F. W. MERRILL, M. E.

### Hot Ashes and Cold Water Burst Cement Floor.

EDITOR THE PRACTICAL ENGINEER:

As something occurred the other day in a boiler room which was never before experienced by the engineer or the fireman during their time of service, I thought it might be interesting to the readers of THE PRACTICAL ENGINEER as well as a caution for the prevention of what can happen again with more serious results.

Two boilers constitute the battery in the boiler room referred to; one had been cut out for cleaning purposes and as the other boiler was forced all the time to keep up steam, the fireman had to hustle to clean his fire. When cleaning, he pushed the fire back and drawing the ashes that were left, as hot as could be faced, he levelled off the fire again and proceeded in the usual way to flush water on the ashes to cool them down.

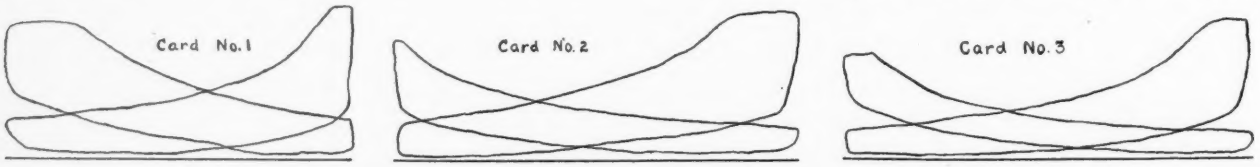
Suddenly, like the report of a gun, the cement floor under the ashes blew up but luckily did not spread or the fireman would have been hurt. My opinion was that the hot ashes had made the cement floor very hot and the sudden rush of cold water made the floor act like a red hot boiler and burst it up. This is my view; others may think different. However, the above illustrates an accident that should be guarded against.

Phila., Pa. P. H.

### Examples of Bad Reducing Motion.

EDITOR THE PRACTICAL ENGINEER:

I am enclosing three cards that have been very instructive to me and I think they might also prove instructive to other readers of your paper. They were all taken from the same engine with the same valve adjustment and practically the same load and steam pressure. The difference was caused by the reducing motion.




**Examples of Incorrect Reducing Motion.**

Cards were taken by the builders of the engine during the trial run, the reducing motion being sent from their shop. I protested from the first that it was not accurate but was told that it was the design they always used. Card No. 1 was taken with this arrangement but as we could get no satisfactory results from any valve adjustment we made, we studied the reducing motion more carefully. We found that there was more error on one end of the stroke than on the other and after dividing the error, approximately, between the two ends, card No. 2 was taken. We then stripped the whole thing off the engine and made a pantograph and led the cord off parallel to the stroke. We then got card No. 3.

The cards are from the high-pressure cylinder of a high-speed compound engine running with the low-pressure piston removed and no receiver. The cards are not presented as examples of good steam distribution but as good examples of bad reducing motion.

Phila., Pa. A. L. H.

### Troubles with Check Valves.

EDITOR THE PRACTICAL ENGINEER:

Some time ago I had a tank pump, of the belted power pump pattern, that was giving me trouble, as I had to prime it when starting every morning and at noon. After overhauling the valves and piston, which did not improve it, I noticed that the pump did not get water enough and knowing that the suction pipe was large, I looked for leaks, but could not find any. I then opened the check valve on the suction pipe and found the trouble. The valve was off the hinge, allowing it to block the outlet when the pump was running and to fall away when the pump was stopped, thus allowing the water to get out of the pipe back to the source of supply. I made a hinge from a 1¼" x ⅛" piece of wrought-iron and then started the pump and it worked fine. I then took the old hinge, plugged up the holes with wood and sent it to a brass foundry and had some hinges made from it and then put one of those brass hinges on that check valve and it is there yet.

About one month after making the above change, the fireman reported that the belt that drove the counter-shaft to the boiler feed pump was off the pulley. I asked him if he had valves on the boiler feed all open and he said he had. I then put the belt on and the pump ran for about five minutes and then it jumped off again. I then put in on again but it jumped off again. My check valve trouble came to my mind and I started a steam pump to feed the boilers and examined the check valve on this line of pipe. I found the same old trouble, the valve off its hinge, stopping up the discharge of that pump, but as I had spare hinges, it did not take long to make repairs on that job.

Some makers of iron-body check valves use a cast-iron or malleable iron hinge on the valve or clapper; that is, on what is called straight away valves. Now, I think that it would be far better to use brass and I don't think that the extra cost will amount to anything. I do know it would save trouble, and that in itself would pay for putting in a brass hinge instead of cast-iron or malleable iron. I think that certain waters have the effect of causing some kind of galvanic action which destroys the iron that is in contact with the brass valve.

Fall River, Mass. M. H. H.

### Banking Fires.

EDITOR THE PRACTICAL ENGINEER:

In reading over the articles on "Banking Fires," I quite agree with M. C. R., that leaving fire-doors open will cause the tubes to leak, as I have had some experience in going under a boiler on Sundays to expand leaky tubes, which I believe was caused by leaving the fire-doors open.

In talking with an engineer of an adjacent plant, I related the way I banked my fires and he said I should try this method, which I did. In the plant where I am employed as engineer, I have to do my own firing. The engine was started at 7 A. M. and stopped at 5 P. M. So at 4.30 P. M. I throw on 4 or 5 shovelfuls of coal back against the bridge wall in one corner of the furnace, and then one or two shovelfuls on the fire, the bank helping to hold steam up. In about 10 minutes, I put one or two more shovels of coal on my bank and at 10 minutes before 5 P. M. I put 3 shovelfuls of fine coal or slack over the bank, letting steam drop about 15 pounds until shutting-down time. Then I close ash-pit and fire-doors as close as possible, also closing damper nearly all the way and opening flue cap door about 10 inches. I would leave the boiler in this manner until about 6.15 the next morning, when I would always have a good bank of fire and 40 to 50 pounds of steam.

The next morning, I take my fire hoe and pull everything off the grate bars, then I pull the bank over onto the grates

and throw a couple of shovelfuls of coal on it, opening ash-pit doors and damper wide and closing flue cap door. If I wanted to, I could start in 20 minutes but usually after my fires started in good shape, I checked ash-pit doors and damper and would do what repair work was necessary in and around boiler, pump or engine, such as keying, packing or cleaning the plant. Here I would like to say that too many jobs are left to be repaired on Sunday. I think that is all wrong, for most engineers have time during the week and most Sunday jobs are done in a hurry, just so they are done.

I followed the above method of banking fires for 5 years and have put a bank in on Saturday night and had a nice fire on Monday morning and the bank was not large either, so in sending this to the readers, I hope they will find it O. K.

Columbus, O. L. A. C.

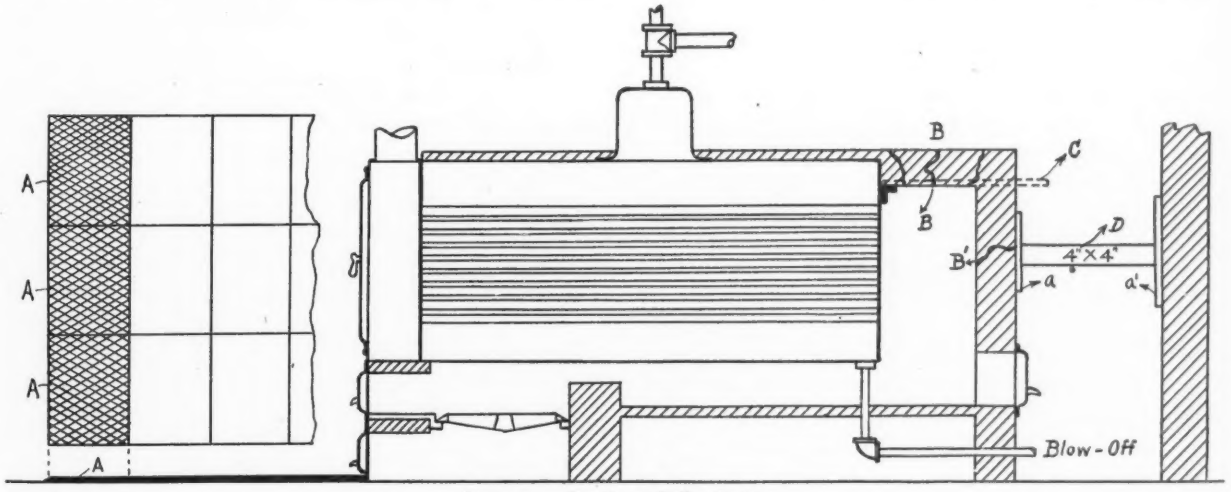
### Emergency Repair to Boiler Setting.

EDITOR THE PRACTICAL ENGINEER:

A short time ago, a neighboring engineer called me in to see if I could give him any information regarding the draft of his boiler; he said he had been on the job for about two years and everything had gone along all right until within a few days. I questioned him carefully regarding the dampers, damper regulator, and clean-out doors and according to his statements, everything was in good order; so we went to his plant to look around and to locate the trouble, as the engineer was very anxious to find it, for the factory was very busy at the time and the loss of one day would mean the loss of many dollars to them. My first little search revealed the trouble, which is quite plainly shown in the accompanying sketch at B and B′. There were cracks open large enough to admit one's hand.

The first thing I suggested was to fill up the crack in the rear of the setting, as is shown at B′, with asbestos cement, and then put up the 2″ planks at a and a′ with a piece 4″ x 4″, shown at D, as a shore to prevent the setting from falling down entirely. On examination of the top at B, it was found to be almost entirely crumbled away, so that it could not be temporarily repaired with cement of any kind, so I suggested the only thing to do that I could think of, and that was to take up three of the floor plates, as shown at A, and as the loose bricks were removed enough to allow it, a plate was placed as is shown at the dotted lines at C. It took but a short time to put these three plates up at the rear of the setting and where they came together, a liberal supply of asbestos cement was put, and the entire thing covered with a thin layer of dirt. This repair held for a short time, in fact, until a mason could be given time to make the necessary repair to the entire boiler setting, and in the future, we think, a certain engineer we know will look around a little more, or in other words, keep his eyes open wider.

Depew, N. Y. C. W. D.




Emergency Repair to Boiler Setting

### Four Good Reasons for Sticky Corliss Valves.

EDITOR THE PRACTICAL ENGINEER:

I must say I have been amused at the communications in relation to the question as to why the valves of a Corliss engine stick. Everybody seems to blame the dash-pot for all the trouble, when if the facts in many cases were known, it would be found that the dash-pot had nothing to do with the trouble.

I have been handling dash-pots in connection with Corliss and Greene engines for thirty-five years and have very rarely found any trouble with a fairly good dash-pot. The reasons why Corliss valves stick or are closed with two motions, are four good ones: First. In nine cases out of ten it is due to poor lubrication, especially if the valve stops part way and then closes; just a little more oil will stop this and the valve will close all right. To illustrate this, I was once called upon by a friend to suggest a remedy for his Corliss valves sticking. I sat down with him beside his engine for two hours and during that time not one drop of oil passed through the lubricator. We started the lubricator and the trouble disappeared. The second source of trouble is in packing the valve stems too tightly or by letting the packing stay in too long, in which case there is no good way to lubricate the stem and the friction is so great upon the valve stem that the dash-pot cannot handle it. The third cause is the use of too stiff springs in valve blades for the purpose of holding the valve onto the seat. The fourth case may be poorly adjusted air valves in dash-pots.

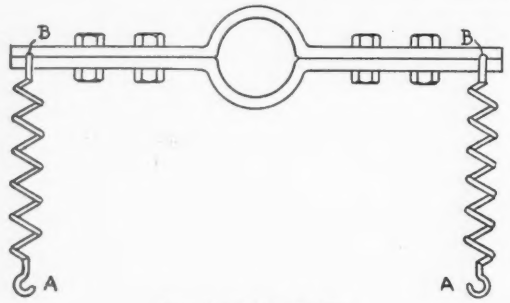
Now, it is easy to see that if each one of the above causes contributes just a little to the valve sticking, it will result in a lot of trouble.

Watertown, Mass. H. M. G.

### Sticky Valves.

EDITOR THE PRACTICAL ENGINEER:

On page 25 in the March issue, Mr. N. L. says that he has trouble with the steam valves of his Corliss engine sticking when the load is light and the pressure high. On one occasion I had the same trouble with an old Corliss engine and after making several trials, I could not get any improvement, so I decided to make the valve close by means of two spiral springs and a clamp, which are shown in the accompanying




Cure for Sticky Valves

illustration. The springs I used were ½" outside diameter and 12" long. The ends AA were fastened on the floor by means of ½" hanger screws and the other ends BB were hooked on the clamp, which was fastened on the rod by means of 4 bolts. I made it this way so that the rods will drop straight down.

Boston, Mass. V. M.

### Lead on Locomotives.

EDITOR THE PRACTICAL ENGINEER:

If an engine has port opening enough to fill clearance space to full boiler or steam line pressure the instant the piston is at the end of the stroke, then it is obvious that changing the lead so as to make it less would necessarily decrease the force or impulse the piston would receive at the beginning of the stroke. However, the lead can be made so excessive that it would tend to decrease the speed and power, and in this case we would be consuming the energy stored in the driving wheels and reciprocating parts of engine to compress live steam.

That the proper amount of lead will enable an engine to take a load and get up to speed, and also respond to fluctuations in load more rapidly than when valves are line and line is a self-evident proposition. This statement will apply to stationary engines. But for locomotives lead is not a necessity and under certain conditions becomes decidedly objectionable.

One of the largest railroad companies east of the Mississippi some years ago purchased a number of large improved locomotives which were put in service with about $^1/_{16}$" lead. After a short period of continuous duty, an examination was made of cylinders and it was discovered that the piston had worn a shoulder at each end of cylinder at the top of bore as shown at A and B, Fig. 1. This sketch is greatly exaggerated for the purpose of making it plain. At one terminal of the division, a portable boring bar was kept in service nearly all the time reboring cylinders. After a consultation of engineers and master mechanics it was decided to take off the lead and bring valves line and line. This was done with the result that cylinder wear at that point was no more evident and reboring was reduced to a minimum.

The writer has frequently interviewed engineers on this problem, and so far has been unable to get an expression of opinion regarding the manner in which lead would cause this abnormal wear in cylinder.

There is an old saying that, "fools rush in where angels fear to tread," but we take notice that after the path has been well beaten, even the angels are not afraid. With the editor's permission we will present a theory of the cause of the trouble, and while it may be wrong, it has the merit of being entirely original.

By studying Fig. 1 we will see that we have two forces acting (as engine stands) almost in opposition: First, the steam acting on the head end of piston, which we will designate by arrow 1. Secondly, the force tending to oppose the movement of the piston shown at 2. Just at this position the valve is open the extent of the lead, and the pressure of the crosshead is downward on the guides. But at the instant the crank passes the line of centres, the piston and rod with crosshead and main rod are exactly in line, then all the force of the steam is exerted against the main pin. Now if the piston and rod together with the main rod and crosshead were just a little above the line of centres passing through the main shaft, then the excessive pressure, due to the early admission, would cause the piston to strike the upper part of cylinder bore, because the piston has for the instant become a hammer and the rod, crosshead and main rod, the handle.

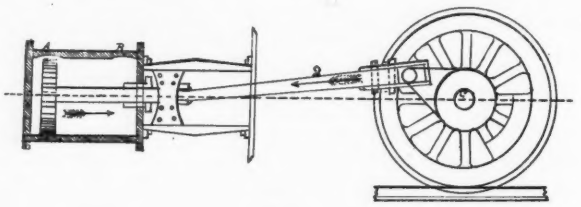


Fig. 1

It will now be seen that if the main shaft or driving axle were raised so as to be slightly above the line of centres then the pressure on piston would tend to move or hold piston to bottom of bore. In order to make this point clear, one must imagine the piston and rod, the crosshead and main rod revolving around the centre C of the main shaft; and if while the piston were on the dead centre and force applied in the direction of arrow 1, the piston would move up if the centre C were raised. We would be pleased to read in the columns of the magazine the opinions of others who are interested.

Columbus, Ohio. JOHN BURNS.

### Size of Safety Valve.

EDITOR THE PRACTICAL ENGINEER:

I saw a question in your April issue in which a brother engineer at Cornwall-on-the-Hudson, N. Y., wished to know the size or area of a safety valve for a 60 horse power boiler at 90 pounds pressure. I would say to him that the Hartford Steam Boiler and Inspection Co. say that a 3-inch safety valve

is the size for a 60 horse power boiler at 90 pounds pressure. They have condemned the size of safety valve of 2½ inches on our boilers and also on others of 60 horse power and they say we must have a 3-inch valve with a 3½-inch outlet from valve to atmosphere.

Berkshire, Mass. W. H. R.

### Three-Way Valves.

EDITOR THE PRACTICAL ENGINEER:

As some of your correspondents do not seem to understand what a three-way valve is, I submit the following information:

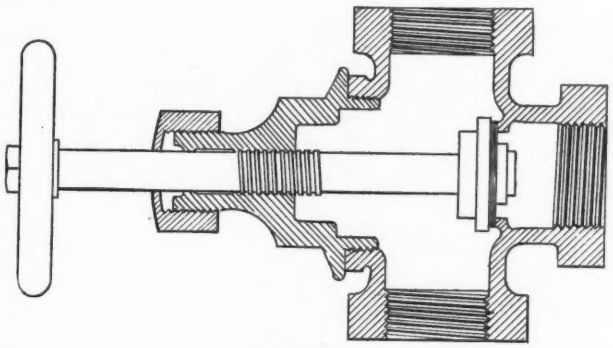


Fig. 1

Fig. 1 illustrates what is sometimes called a three-way valve, but it is not. The stem of this valve controls but one opening and that is at the right as it now stands. It has no effect whatever on either of the vertical openings but owing to the fact that they are at right angles to the stem, it is called a cross-valve.

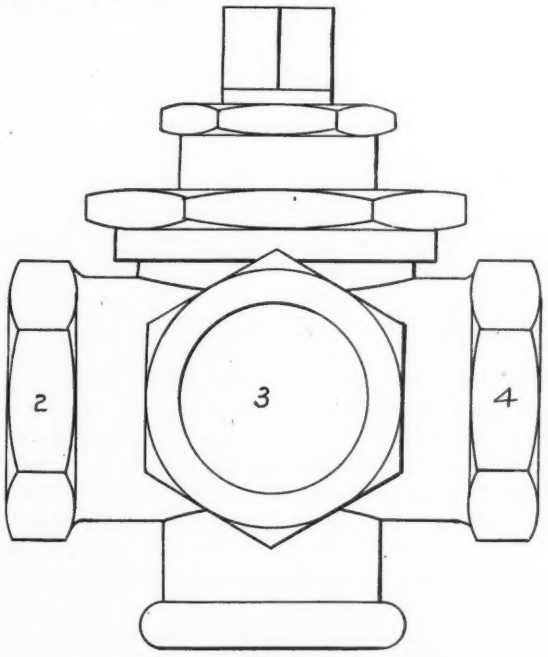



Fig. 2

Fig. 2 is called a three-way valve by the firm who makes it, but it is more commonly called a three-way cock. The plug or stem of it controls all three of the openings, as it can be made to close 2, 3 and 4 in succession, therefore it differs widely from the cross valve and the names should not be used indiscriminately.

New Haven, Conn. W. H. WAKEMAN.

### What Would Prevent Compressed Air from Forcing Water into Boiler?

EDITOR THE PRACTICAL ENGINEER:

My idea of this question is as follows: In an injector, the steam nozzle is so constructed that its outlet is much smaller than its inlet, thereby obtaining a very great velocity of the steam which is strong enough to force a body of water through the feed pipe, lift the check valve and overcome the boiler pressure after having formed a partial vacuum in the mixing space and imparting a part of its heat energy to said water.

But what I would like to know particularly is: "What would prevent compressed air from being used instead of steam for forcing the feed water into the boiler?

Hoboken, N. J. P. J.

### Water in Cylinders Wrecks Three Engines in S. Boston, Mass.

Thirty-five separate manufacturing concerns, employing an army of help, were forced into temporary idleness a few days ago in S. Boston, Mass., by an accident which resulted in the wrecking of three 200 horse power tandem compound engines.

The cause, it is claimed, was the backing up of water from the condenser, through the exhaust piping, into the low-pressure cylinders of each engine. Fortunately, no one was injured.

The accident happened before 7 A. M., in the power house of the Factory Buildings Trust, corner of A and Wormwood Streets, which plant supplied power, electrically transmitted, to the various manufacturing industries, in the buildings of the Trust. The equipment consisted of three 200 horse power tandem compound Fitchburg engines, direct-connected to G. E. generators and one Westinghouse Junior direct-connected set.

On the morning of the accident, the operating engineer started up engine No. 1 in the usual way. This engine carried the early morning load of three elevators and at the time no irregularity was noticeable to warn him that anything was the matter with the machine. Engine No. 2 was started up about 15 minutes later and kept turning over with steam through by-pass only. Then engine No. 3 was put in operation but made less than half a dozen revolutions when the accident happened, and all three engines practically flew apart in quick succession. Engine No. 1, which was under light load, received the most damage; broken base and crosshead, cracked high- and low-pressure cylinders, and the cylinder head blown out. Engines Nos. 2 and 3, possibly, can be repaired, as the principal damages to be seen, without careful examination, are the broken bases which in any case will have to be replaced.

The engines were practically new, having been in use less than two years and were giving excellent service.

The draft necessary for the combustion of a given amount of coal depends upon the velocity of the escaping gases of combustion, the friction of the air through the fuel into the furnace and the friction of the gases from the furnace to the top of the chimney.

# QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

## Power Required to Drive a Boat or Car. Lines of Force. Electrical Theories.

EDITOR THE PRACTICAL ENGINEER:

Will you please answer these questions in your next issue?

(1) Why does the power required to drive a boat in the water vary as the square of the speed? I imagine it is because there is so much water moved with the boat, but I think there are other reasons.

(2) Why does the power required to drive a street car, or to move anything through the air, vary as the square of the speed?

(3) Please explain the unit line of force they use in designing pole pieces, air gaps and armature teeth of dynamos. What do they call a unit line of force, how is it known and how many lines of force per square inch do they have in the pole pieces, air gap or armature teeth?

(4) Do we charge particles of matter and then move the charged particles over the conductor or are the particles charged all the time and the dynamo just sets them in motion, or do the particles of the conductor charge one another on the same principle that heat is conducted through a solid bar?

(5) What is the double and single fluid theory that we hear so much about?

(6) Do we generate the electricity itself or the force?

Weehauken, N. J. E. W.

(1) The power required to drive a boat varies, in round numbers, as the cube of the speed and not as the square, as mentioned. The horse power required may vary, however, from the 2.8 power to the 3.5 power, depending upon the lines of the vessel and upon the efficiency of the machinery. The increased horse power required for increased speeds is chiefly due to the increased resistance of the ship in the water.

(2) The horse power required to drive a street railway car at ordinary speeds varies with the traction effort and the space traversed. The traction effort depends upon the resistance of the car, which in turn depends upon the friction of the journals, speed, grade curvature of the tracks, etc. Just how much the wind resistance increases the horse power when a car is travelling at high speeds has not been clearly determined and no rule can therefore be given. An approximate rule, which is sometimes given, states that the resistance in pounds per ton $= \frac{1}{4}$ velocity in miles per hour $+ 2$.

(3) The fact that there are lines of force issuing from a magnet has always been assumed and the modern magnetic theory, upon which are based all magnetic calculations, assumes that they are always present in a magnetic field. The thought of line of force was first derived from the fact that when iron filings are scattered over a piece of paper, they will arrange themselves into curves corresponding to the so-called lines of force and forming the magnetic field. The whole subject is therefore really an analogy rather than a proved theory.

A line of force is always closely associated with an electromagnet, the magnetism of which depends upon the number of turns of wire, the strength of the current and the resistance of the magnetic circuit, called reluctance. A line of force can therefore be defined as that force which is produced by a unit magneto-motive force through a circuit of unit reluctance.

In the design of a generator, one of the first assumptions made is the density of the air gap and it will depend upon whether the pole pieces are made of cast-iron, wrought-iron or steel. The density is also greater in the case of multipolar machines than in the case of bipolar machines and it increases, within limits, with the size of the machine. A value of between 4000 and 7500 lines per square centimeter is therefore chosen for the air gap, which is equivalent to 26,000 to 50,000 lines of force per square inch. The density of the armature teeth usually varies from 17,000 to 23,000 lines per square centimeter, which is equivalent to from 110,000 to 130,000 lines per square inch or near saturation. The fields will usually contain from 8000 to 15,000 lines per square centimeter. All these values, however, depend upon the design and type of machine and the materials out of which it is made.

(4) This is a subject that has been much discussed and new theories are still being advanced as to the flow of electricity and the theory of magnetism. It is well-known, however, that electricity acts like an incompressible fluid, so that when one portion of a conductor is charged, the whole circuit becomes immediately charged just the same as when pressure is exerted on the end of the water in a horizontal pipe, the whole hydrostatic system would exert that same pressure per square inch. This is done both in an electrical circuit or a hydraulic circuit with a rapidity which can scarcely be calculated.

(5) Several theories have been advanced to account for various electrical phenomena but they are all more or less unsatisfactory. Symmer proposed the "two-fluid" theory, according to which there are two imponderable electric fluids of opposite kinds, which neutralize one another when they combine and which exist in all bodies in equal quantities until their condition is disturbed. A modification of this theory was made by Franklin, who proposed, instead, a "one-fluid" theory, according to which there is a single electric fluid distributed usually uniformly in all bodies, but which, when they are disturbed, distributes itself unequally, one substance getting more and the other less electricity than the average. Hence the terms positive and negative, which are still retained. It is



quite certain that electricity is not a fluid, whatever else it may be.

(6) While force is required to generate electricity, it is the electricity itself, rather than the force, which is generated. Wherever electricity occurs, it is capable of producing a force. This force may be either in a kinetic or potential form just the same as water when it is elevated to an overhead tank. The water in the tank is always exerting a pressure due to its position, but it will not give out any useful work unless the

water is allowed to flow to a position below it. The electricity in a wire is always producing a force, whether that force is potential or kinetic. The terms force and electricity are therefore inseparable but in practice it makes no more difference which is created than the old problem of which was made first—the hen or the egg. In general, all the above electrical questions depend upon whether electricity belongs to that division of physical phenomena, known as energy, or whether it is matter, just the same as air, water or coal. It may also be neither one of the great divisions of physics and may probably belong to a class by itself.—[Ed.]

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**Setting Valves on a Rice and Sargent Engine.**

EDITOR THE PRACTICAL ENGINEER:

What is the best method of setting the valves on a Rice & Sargent engine?

Pawtucket, R. I. D. V.

The Rice and Sargent engine is a four-valve, releasing gear engine, having rotary multi-ported valves, separate eccentrics being used for driving the steam and exhaust valves. The releasing gear used is shown in two positions in the accompanying diagram. The lever *L*, operated from the eccentric by the rod *A*, carries the block *C* keyed to one end of a short shaft, to the other end of which is keyed the trip lever *G*, which slides between two rollers *EE* mounted on pins carried by the lever *H*, which is connected to the governor by a reach rod, *D*, and takes the place of the usual knock-off cam.

In operation, as the eccentric rod *A* moves in the direction indicated, the block *C* engages the catch block *B*, mounted on block M, which is keyed to the valve stem. When the point of release is reached, the trip lever *G*, owing to its peculiar form, is thrown outward, releasing the catch block *B*, allowing the drop lever *M* to be drawn down by the action of the dash-pot.

For setting the valves, see that all connections are so adjusted that the rocker levers are plumb, then turn the eccentrics around on the shaft and see if the eccentric rod is adjusted so that the levers will travel equally each side of the plumb line. Now place engine on the forward centre and make coinciding marks on the crosshead shoe and the slide, then move engine backward so that these lines will be ¼″ to $^{5}/_{16}$″ apart, then move steam eccentric around on the shaft so that the valve and port will be line and line, and moving to open.

For the exhaust on the high-pressure side, move the engine back about 3½″ and set eccentric so that valve and ports are line and line and moving to open the proper valve. Then turn engine on to the back centre and do the same thing, only turn engine back more than 3½″ and then move engine up to the marks the way the engine is to run, so as to get out all back lash. If marks do not come exactly the same as at the front end, make up half the difference on the eccentric rod and move the eccentric so the lines on valve and ports come together again. Then go over the whole setting again. Try at all times to keep the length of the rod connecting the two rocker levers so that the two levers will be plumb at the same time.

On low-pressure side the steam valve should be set to open about ⅜″ from end of stroke and exhaust valves from 6″ to 8″ from end of stroke.

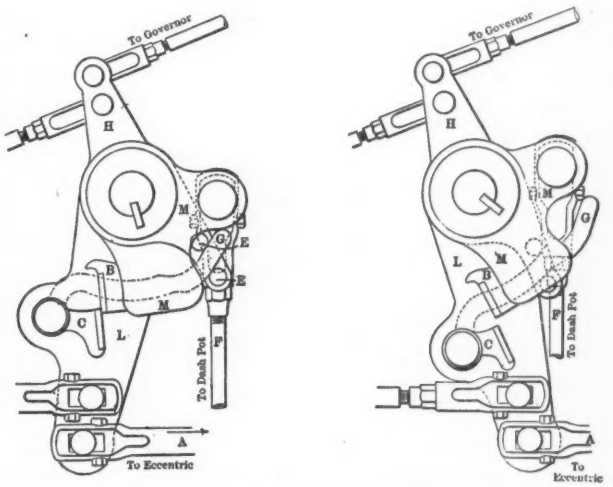
On tandem engines make a mark on front end of high-pressure sole plate clamp when engine is cold, then note the amount the high-pressure cylinder moves back after the engine is thoroughly heated, then lengthen out the long clutch rods the same amount. This will make valves in high pressure about the same as if set with engine hot.

The steel plates on latches and toes should lap by each other when engaged, $^{1}/_{16}$″ on cylinders up to 22″ diameter; $^{3}/_{32}$″ on cylinders from 24″ to 30″ and ⅛″ on cylinders above 30″ diameter.

The "gap" or distance the steel plates move by each other before engaging is adjusted by the dash-pot rod and should be kept as small as practicable; $^{1}/_{16}$″ on small cylinders to ⅛″ on larger ones.

All parts of the governor should work freely and all cut-off connections should shake freely endwise on their pins. Governor cross-shaft must be perfectly free.

Governor may be made more sensitive by screwing one or both the plugs out of the spring, and less sensitive by screwing those plugs into the spring. One half turn of one plug is enough for a trial. This operation necessitates taking the spring out of the governor and putting it into a vise.




Releasing Gear of the Rice & Sargent Engine

To make the engine run faster, turn the spring on its screws so as to put more tension on it. The reverse operation will make the engine run slower. One turn of spring will usually make a difference in speed of about one revolution of the engine.

In adjusting the cut-off rods for high-pressure side of compound engines and for simple engines, adjust the rod from governor to forward valve gear so that the latch at the front end of cylinder will just let go for the latest cut-off, with governor on stop. A good way to determine this is to adjust rod with engine running slow, so that latch will barely hold on and not let go. Then shorten the rod about one half turn and the latch will always be sure to let go and give the governor the greatest range of cut-off obtainable. Also when the governor is at the top or bottom of cam slot the latch should clear the toe and prevent opening of steam valve. Then square up the cut-off by adjusting the cut-off rod between the front and back bonnets.

In adjusting the low-pressure cut-offs, get the valves square,

so that the cut-offs will be equal on front and back ends, by means of the cut-off rods between the front bonnets. Then adjust the cut-off rod from governor cross-shaft so as to get the receiver pressure desired. This with steam pressure of one hundred to one hundred fifty pounds for rated load on condensing compound engines will be in the neighborhood of ten to fifteen pounds; on non-condensing compound engines, from thirty-six to forty pounds.

Low-pressure cut-off should always be so adjusted as to allow low-pressure steam valves to open slightly when governor allows toe and latch to pass each other on high-pressure side. This adjustment is made when the proper receiver pressure is obtained. This adjustment will prevent racing on light loads and in getting ready to put on load.

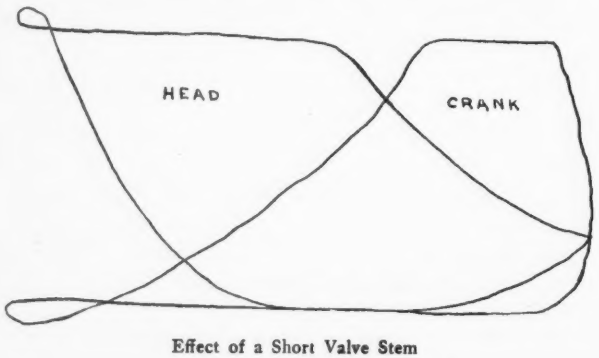
### Reasons Why Injectors Fail to Work. Cards from a Short Valve Stem Engine.

EDITOR THE PRACTICAL ENGINEER:

We had one of our engineers go up for a first-class license recently. He was well posted and a man of experience but he could not pass the necessary examinations for a license. Among the questions that were asked him, was: "Give 15 reasons why an injector will not work." He got up to nine, then stuck. Another question was: "Draw an indicator diagram of a slide valve engine with short valve stem, showing both ends of the cylinder." Will you please give solutions to the questions?

Lowell, Mass. R. W. P.

The principal reasons why an injector fails to work is as follows: Absence of water at the supply, strainer clogged up, the suction pipe stopped up, a leak in the suction pipe, suction water too hot, lack of proper steam pressure for the lift, dirt in delivery tube, faulty check valve, loose disc in globe valve, the injector may not be started properly, it may not be properly connected to steam supply, the internal tubes may become worn from use, sudden variations in steam pressure may break the feed, piping of the injector may be too small.




**Effect of a Short Valve Stem**

A shortened valve stem means a decrease of steam lap and increase of exhaust lap on the head end and an increase of steam lap and decrease of exhaust lap on the crank end. The effect of decreasing the steam lap is to make cut-off later and admission sooner and the effect of increasing the exhaust lap is to make the exhaust open later and close sooner. The effect of increasing the steam lap is to make cut-off earlier and admission later and the effect of decreasing the exhaust lap is to make the exhaust port open sooner and close later. The accompanying cards will show a fair sample of what might be expected with a short valve stem.—[Ed.]

### Volume of Frustum of Cone and Pyramid.

EDITOR THE PRACTICAL ENGINEER:

Kindly answer the following questions:

(1) A frustrum of a cone is 9 feet in altitude and the bases are 11 feet and 8 feet 7 inches in diameter; what are its contents?

(2) A cylindrical cistern 11 feet deep and 7 feet in diameter contains 3166.7 gallons; what is the surface exposed to the water?

(3) How many cubic feet are there in a piece of timber 15 feet long, 16 inches square at one end and 12 inches square at the other?

Ewa, Hawaiian Islands. J. S. P.

(1) The rule for finding the cubical contents of a frustum of a cone is as follows: Add together the area of the two bases and a mean proportional between them and multiply the sum by one-third of the altitude; the result will be the volume. To find the mean proportional between the two bases, multiply the area of the two bases together and extract the square root. Worked out according to the above rule, the volume of the given frustum is 680.88 cubic feet.

(2) Since 7.48 gallons equal one cubic foot, 3166.7 gallons equal 423.3 cubic feet. This volume of water is equivalent to the cubical contents of the tank. If the tank has no top, the surface of the tank exposed to the water is the area of the bottom and area of the sides. The area of the bottom is 38.485 square feet and the area of the sides is $7 \times 3.1416 \times 11 = 241.9$ square feet, or a total of 280.3 square feet.

(3) The shape of this piece of timber is called the frustum of a pyramid and its volume is found in the same manner as the frustum of a cone, *i. e.*, add together the area of the two ends and a mean proportional between them and multiply the sum by one-third the length. The number of cubic feet in the timber 15 feet long and 12 inches square at one end and 16 inches square at the other is therefore 35,520 cubic inches, or 20.55 cubic feet.—[Ed.]

### Economical Methods of Feeding Boilers.

EDITOR THE PRACTICAL ENGINEER:

Which is the most economical method in a steam plant for feeding boilers? Some say belt pumps are the best, others say duplex steam pumps are the best, while others think injectors should be used. Which is the most economical of the three?

Exeter, Canada. N. L.

It depends entirely upon the conditions as to whether it is most advisable to use either a belt pump, a duplex pump or an injector. If there is a feed water heater in the plant and the exhaust from the engine does not heat the feed water to at least 200 degrees, then a duplex feed pump would be advisable, since all the exhaust steam from the pump could be made to go into the heater and thus the heat lost in the pump could be regained. If, however, the feed water is hot enough and there is no use for extra exhaust steam, then a belted pump would be more economical on the principle that the power necessary to pump a given quantity of water can be more economically supplied by the main engine than when a

duplex steam pump is used. In a third case, where the feed water is being fed cold into the boilers and the plant is not equipped with a feed-water heater, then an injector would be the most economical, since all the heat in the steam used by an injector is given up to the feed water and its thermodynamic efficiency is 100 per cent. Whether, therefore, any one of the three should be used in preference to the others depends upon conditions.—[Ed.]

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**Water Required for a 225 Horse Power Engine.**

EDITOR THE PRACTICAL ENGINEER:

It has been a subject of much importance about here as to the amount of water that a pump will have to furnish for 3 boilers. These boilers furnish steam for a 225 horse power engine which runs the works. That is all the work the boilers have to do. Let me know how many gallons per hour the pump should furnish.

River Point, R. I. T. B. H.

An ordinary engine uses about 30 pounds of water per horse power per hour, so that if the engine is developing 225 horse power, this is equivalent to 6750 pounds per hour. Since the boilers only feed water to this engine and considering that there are no leaks in the boiler, the feed pump would only have to pump this amount of water. As there are approximately 8 pounds of water to a gallon, this 6750 pounds is equivalent to 845 gallons per hour.—[Ed.]

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**Lead. Economy of Cut-Off. Injector Economy.**

EDITOR THE PRACTICAL ENGINEER:

1. Why does a high-speed engine require less lead than a low-speed engine?

2. A local traction engine has two notches on each end of quadrant, so that the engine will cut-off at full and half stroke. When taking steam at half stroke, the speed is right, but the engineer filed a new notch, taking steam about ⅜ stroke, and to get speed had to raise the governor stem. Does he gain anything?

3. When you use an injector all the steam goes back into the boiler, besides heating the water, and when using a pump the steam escapes and don't heat the water. Which is the more economical?

4. Does the piston when it is pushing against steam that does not exhaust make what is called compression? Would more lead make more compression or less?

Tekamah, Neb. F. E.

1. A high-speed engine requires more lead than a low-speed engine.

2. The engineer gains economy by his method. But cutting off at ⅜ stroke, he uses less steam, and by raising the governor he gets a higher pressure. To obtain a higher pressure only a small amount of additional heat is necessary and by cutting off ⅛ of the stroke sooner a comparatively large amount of steam is saved, so that in the end the engine should show more economy.

3. In the given case, an injector is the more economical.

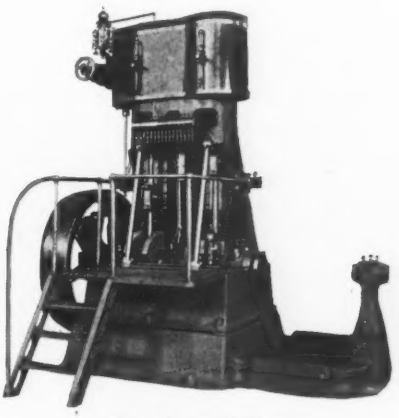
4. As soon as the exhaust port closes and the piston is pushing against the steam that is confined in cylinder, compression begins. More lead closes the exhaust port sooner and naturally makes more compression.—[Ed.]

**The Reeves Engine.**

The newest type of Reeves engine, shown in the accompanying illustration, embodies not only all the well-known features which have made this engine such a favorite among many power users, but also some new improvements which add to its refinement.

The newest improvement allows a perfect separation of the water seepage of the piston rod stuffing box from the guide and crank chamber, which not only improves the lubricating qualities of the oil but renders it possible to use the oil over and over again. The crosshead guides have also been remodeled and are designed so as to give liberal bearing surfaces.

The engine shown is of the vertical type which gives the minimum amount of friction on the pistons and valves and at the same time all parts are easily accessible. The steam is distributed between the high- and low-pressure cylinders so that the work is equalized, but the cylinders are so designed that either cylinder can be used independently of the other, should necessity require.



The Reeves Engine

The valve gear is designed so that a Corliss effect is obtained in the steam distribution. Two valves of the piston type are used for this purpose which can be adjusted and compensated for wear if necessary. The first and smaller of these valves admits steam to the high-pressure cylinder and is controlled by the governor and as the valve is always balanced, the governor has a very light load and controls the speed within narrow limits. The second valve governs the compression in the high- and low-pressure cylinders and admits steam to and controls the exhaust from the low-pressure cylinder. It is driven by a fixed eccentric and always gives a predetermined compression in both cylinders. The steam is admitted directly from the high-pressure cylinder into the low-pressure cylinder and since no receiver is used, no steam is expanded uselessly.

A particular feature of the Reeves engine are the patented valves which are used on all types of this engine. They are of the adjustable piston type and are so designed and constructed that either end of the valves can, independently of the other, be easily adjusted without removing them from their seats. After adjustment they will remain positively locked as they have no rings that can be displaced or injured by the action of the steam.

All running parts are enclosed in an enameled steel shield,

which excludes the dirt and dust and prevents the throwing of the oil from the engine.

Tests of a vertical cross compound engine 10 x 20 x 14 have shown an economy of 17½ pounds of water per indicated horse power per hour with a mechanical efficiency of 96½ per cent., while tests of a single cylinder engine have shown an economy of 27½ pounds of water per indicated horse power per hour, non-condensing.

A full report of these tests and further engineering information may be had by writing to the manufacturers, The Reeves Engine Co., Trenton, N. J., and 2223 Land Title Bldg., Philadelphia.

**The Climax Accessible Cylinder Lubricator and Sight Feed.**

One of the most economical methods of lubrication is to divide the amount of oil which an engine requires into as small portions as possible and to feed it often. This method is taken advantage of in the Climax cylinder lubricator, shown in Fig. 1. It works on the force-feed principle and embodies features that give it a differential stroke, which makes it slow at suction and quick at discharge, thereby enabling it to feed small drops at short intervals. Any desired feed can be obtained by means of the adjustable locked crank, which allows a throw of the screw arm from near the centre to beyond the periphery of the ratchet wheel, giving a plunger displacement of from $^1/_{32}$" to ¼" and a discharge from a small drop to a stream.

The construction can be seen in Fig. 1, which is a sectional view of the lubricator. The screw rotating in a nut drives the pump plunger in and out of the pump chamber. The throw of the plunger is governed by the throw of the slotted

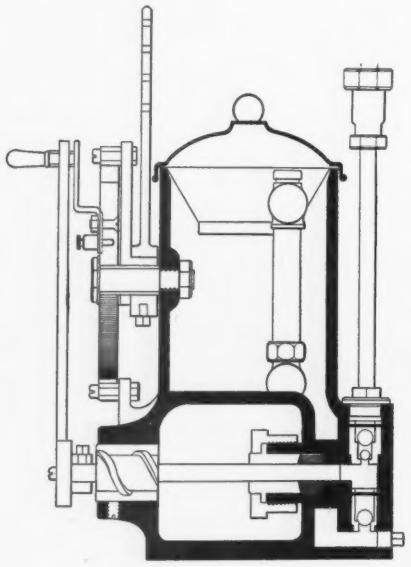


Fig. 1

arm, which is governed by the throw of the adjustable crank pin. This pin may be fixed at eight points, which gives eight feeds from minimum to maximum. All parts of the lubricator are removable, the valve chamber being accessible from the outside. The following conveniences are provided with each lubricator: the hand feed, an indicator for showing the height of oil in the reservoir, a strainer, a clean-out plug by which the reservoir can be emptied and flushed out, a combined spanner for the stuffing box nut and socket wrench for removing the valves.

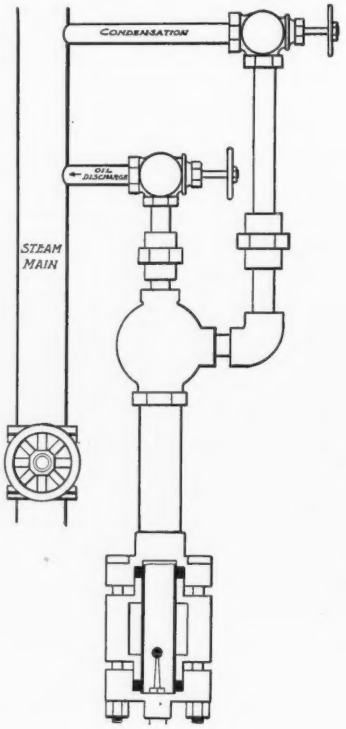



Fig. 2.

The Climax Patent Sight Feed is shown in Fig. 2 and was designed to produce a visible measurable sight feed for oil pumps, which shows the oil at atmospheric pressure before it passes the pump and check valve under pressure. It shows the drop passing upward in a sight glass exactly as in the hydrostatic cup and indicates the amount and regularity of the feed.

The construction consists of the body and a top and bottom cap which are held together by side bolts. A standard ¾-inch gauge glass is used in which the water always remains cold, thereby reducing to a minimum the liability of breakage. For further information address the manufacturers, Climax Lubricator Co., 3 Appleton St., Boston, Mass.

**Smokeless Operation of Wetzel Mechanical Stokers.**

The accompanying illustrations represent the interior of the boiler room of the Hestonville Ice Plant, 52d and Jefferson Sts., Philadelphia, and a view of the exterior showing the smokelessness of the stacks connected to the boilers using soft coal.

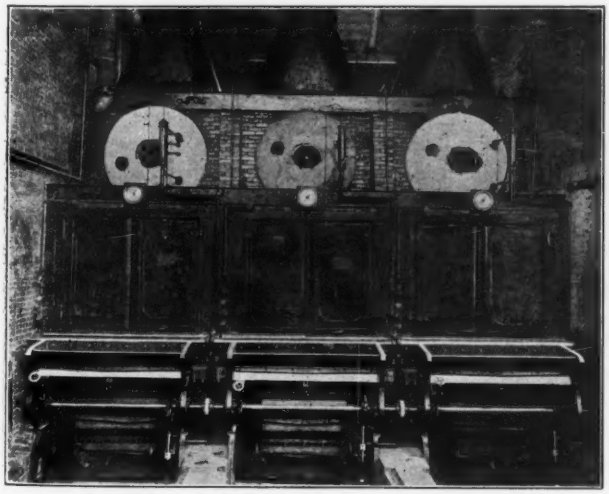
The plant consists of three 200 horse power Parker boilers and each boiler is equipped with a Wetzel Mechanical Stoker. On account of the smoke ordinance in Philadelphia, which is now being more rigidly enforced than ever, the Hestonville plant was compelled to put in some form of smoke prevention device. After a thorough investigation, the Wetzel stoker was decided upon and was installed about six months ago, with the result that since their installation not one ounce of black gas has issued from the stacks.

The stokers have not only prevented the smoke, which is the result of perfect combustion, but they have increased the efficiency and capacity of the plant. Formerly if one of the boilers was compelled to shut down for cleaning or repairs,

Smokeless Combustion of Wetzel Stokers.

the ice plant was compelled to shut down, but the plant can now be run with two boilers owing to the increased steaming capacity of the boilers.

The three stokers shown in the illustration are run by a small engine in the engine room. In operating the stoker, coal is shovelled into the hopper, from which it is automatically pushed to the dead plate and coking grates, where the volatile gases are driven off and mixed with the heated air admitted through the perforated tile of the combustion chamber. The



Three 200 H. P. Boilers equipped with Wetzel Stokers.

coal having been coked, travels slowly down the inclined main grate, toward the dumping grate, receiving air through the grates to complete burning. When cleaning fires, this dumping grate can be operated so that it takes only one minute to clean each boiler grate.

The speed with which the stoker pushes coal on the grates can be regulated to suit any load, while the shake of the grates can be regulated slower or faster according to the amount of ash in the coal.

The Wetzel stokers are also installed in the plants of the New York and Pennsylvania Co., of New York City; Elks Paper Mills, Johnsonburg, Pa.; Lock Haven Paper Mills, Lock Haven, Pa.; Crocker-Burbank plant, Fitchburg, Mass.; Baltimore Refrigerating and Heating Co., Baltimore, Md., and many others. For further information as to the list of users where the stoker can be examined and for a more complete description of the stoker, address the manufacturers, The Wetzel Mechanical Stoker Co., Trenton, N. J.

### The Ruggles Perfection Flue Cleaner.

The metal of the heating surface in most boilers becomes coated with a layer of some non-conducting character caused by the dust and ashes attaching themselves to the plate. This is particularly true of a tubular boiler, where a deposit of dust and ashes will take place, tending to choke the tubes and rendering them less efficient, so that the flues should be cleaned regularly in order to get the best results from the boiler.

The Ruggles Perfection Flue Cleaner, shown in the accompanying illustration, has been designed to clean flues in a thorough manner without any hard physical labor. The cleaner consists of two ends of drop forged steel to which are attached, without any screws or rivets, the cutting knives. The cutters are designed so that they will always be in direct

The Ruggles Flue Cleaner.

contact with the metal of the flues and will override any imperfections of the tubes, such as blisters or welds or any other imperfection therein. The knives are made so that they are very sharp and act like a plane, tending to work deeper all the time. When used on welded flues, the long shearing cut of the knives allows the cleaner to pass over the weld without difficulty. The cleaners are made in all sizes and are on sale by the manufacturers, The Sculley Steel and Iron Company, Chicago, Ill., who will be pleased to furnish any further information desired.

### The Sims Open Feed Water Heater.

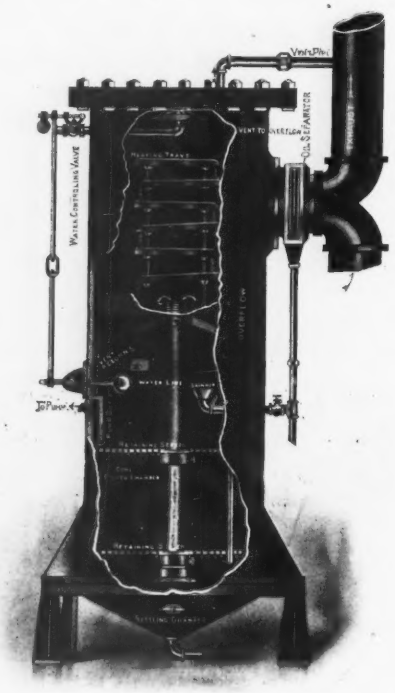
The accompanying illustration shows an Open Feed Water Heater designed and now being manufactured by the Sims Company, manufacturers of steam appliances. Their Closed Feed Water Heater is applicable for many purposes, but as there are places where an Open Heater and Purifier combined are necessary, they have designed this construction, which is fully explained by the illustration and description.

It will be noticed that the feed water flows through an automatic valve regulated by a float in the usual way. The elbow, looking upward, forms a trap which prevents steam

from getting into the pipe, producing the annoying "water hammer" so common to water connections of this type.

The water flows over a convex disc forming a thin sheet falling into a heating tray (there are a series of these trays, number and size according to the capacity of the heater). These are designed to collect the scale-forming matter and cause the water to absorb the heat from the exhaust steam which comes in direct contact with it at this point, finally flowing into a larger tray and overflowing into a pipe passing through the centre of the coke filter to the lower part of the heater.

The water at this point flows off a disc; this prevents any tendency to disturb the muddy water below, and all the impurities sufficiently heavy to precipitate by gravity are removed at this point without coming into contact with the coke filter; the water then ascends through the filter, removing the lighter particles of impurity.



Sims Open Feed Water Heater

This heater is provided with an oil separator, but as an additional precaution a trap is provided over the opening of the pipe which leads to the pump. This trap has a vent-pipe leading into the steam chamber. With this provision it is impossible for any grease or floating scum to find its way into the boilers for the reason that before the water can be drawn down to the bottom of the trap, the suction will break and the pump will cease to draw water from the heater. The suction pipe connecting the heater with the pump is quite high, giving considerable water pressure to the pump, which is of great value when pumping hot water. Another feature is the fact that whenever the settling chamber is blown out, the coke filter will be thoroughly washed, as there will be a rush of water downward at this time. Suitable provisions are made for overflow and skimming devices.

The manner of piping this heater is what is known as the "induction" method; that is, the steam necessary to heat the water is induced to pass into the heater by the impulse given to the same by a special tee (the same results will be accomplished when the exhaust steam passes through the "run" and out of the side outlet of an ordinary tee). A smaller pipe leads from the top of the heater back to the main exhaust line for the purpose of maintaining a circulation, preventing the heater from becoming "air bound." As it is only possible to absorb about 20 to 25 per cent. of exhaust steam in such cases, as when the engine and boiler are of the same size, the boiler performing no other duty, it will be seen that 80 per cent. of the exhaust steam can be piped into the atmosphere or for any other purpose for which it may be required.

These heaters are, however, fitted for "thoroughfare," that is, where all the steam passes through the heater and out at the top. They are also constructed with reference to connecting with heating plants where the returns from the heating system flow back to the heater.

The construction is entirely of cast-iron, including the heating trays, and therefore is not subject to corrosion. They have suitable doors for cleaning purposes and are made in sizes from 50 horse power to 5000 horse power.

For further information, address The Sims Company, 20th St., Erie, Pa., who will be pleased to correspond with anyone who is interested in this type of Feed Water Heater. They will also submit blue prints showing details of construction and sizes.

### The Milwaukee Convention of the A. O. S. E.

The Convention Committee of the American Order of Steam Engineers are going right ahead with the preparations for the Annual Convention of the Supreme Council, to be held in Milwaukee, June 11th to 14th. They advise us that they are meeting with good success in disposing of space for exhibits of steam specialties and engineers' supplies, but still have some space left and are anxious to hear from manufacturers and dealers who contemplate attending the Convention.

The Order is composed of seventeen Councils, with a combined membership of upwards of one thousand. It is expected that there will be upwards of 40 delegates and officers present and also a number of visiting engineers. The committee will make a strong effort to secure the attendance of other Milwaukee engineers whether members of the Order or not. The exhibition hall will be open at all times day and evening. Further information regarding space can be had from Mr. J. T. Harris, chairman, 250 21st St. Milwaukee.

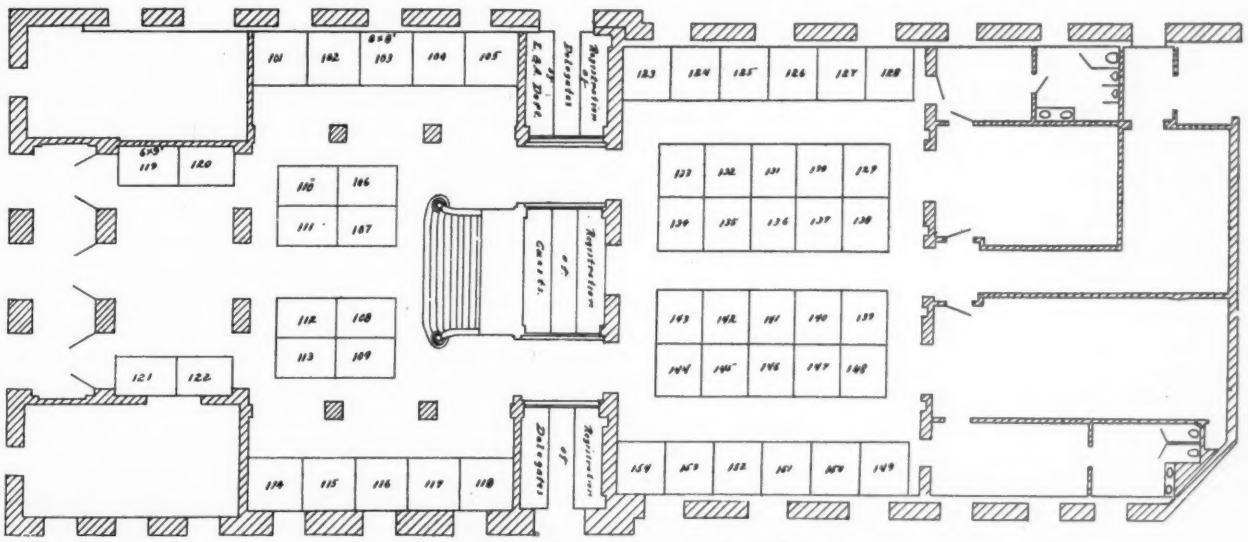
Headquarters will be at the St. Charles Hotel where the committee have secured a special rate of $2.50 a day, American plan. The program of the Convention includes trips to the famous Schlitz Brewery, Soldiers' Home, Whitefish Bay and City Pumping Station, Public Museum and Library, and to Wonderland.

### Aid for Frisco Engineers.

Liberty Association, No. 10, N. A. S. E., of Jersey City, N. J., contributed one hundred dollars to the National Association of Steam Engineers of San Francisco, and extended their heartfelt sympathy to them in their hour of trouble. The money was sent through Brown Brothers, bankers, 54 Wall St., New York.

**N. A. S. E. Convention Plans Progressing.**

The past month has shown the greatest progress in the development of the plans for the next N. A. S. E. Convention to be held in Philadelphia, in September. The local committee has been meeting regularly every week, perfecting plans in for the Convention proper and for the engineers' ball, which is always a feature of N. A. S. E. Conventions, but these features have been well looked after by the committee. Broad Street Theatre, directly across the street from the exhibition hall, is well adapted for convention purposes and the Academy

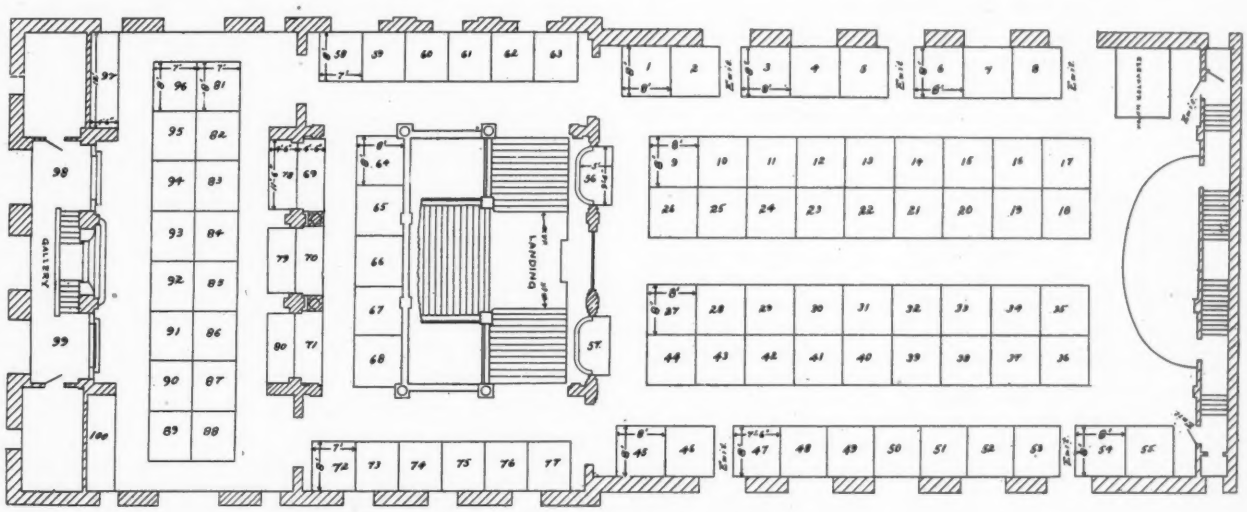


Plan of the First Floor of N. A. S. E. Exhibit Hall

conjunction with the N. A. S. E. Supply Men's Association, so that the Convention will be one grand harmonious week of business, pleasure and intellectual improvement.

One of the finest halls located in the very heart of Philadelphia has been obtained for the Supply Men's exhibits. The large number of inquiries which have been coming in for space have made it necessary to take both the first and second of Music, which is located next door to the exhibition hall, has been the scene of the many social functions.

The floor plans of the exhibition hall are shown in the accompanying illustration. Each exhibition space contains about 60 square feet and until the demand exceeds the supply, two or more spaces will be sold to one exhibitor; otherwise, no more than one can be allotted to each exhibitor.



Plan of Second Floor of N. A. S. E. Exhibit Hall

floors of this hall for exhibition purposes. The second floor is the magnificent ball room, of gold onyx and marble, and when that is filled with engineers' supplies, it is predicted that it will be an impressive sight.

It was originally planned to reserve this fine upper room

For further information about the plans of the Convention or the renting of exhibition spaces, address Richard Pape, chairman of local committee, 919 Ludlow St., Philadelphia, or James McGiloray, secretary of Supply Men's Association, care of Peerless Rubber Co., New York City.

### Book Reviews.

A Practical Manual of Tides and Waves, by W. H. Wheeler, Size, 6 x 9½. 15 chapters, 200 pages and 19 illustrations. Published by Longmans, Green & Co., 91 Fifth Ave., New York. Price, $2.80.

The author in writing this book has given a practical account of the action of the sun and moon in producing tides and also the physical causes by which the tides are affected after their generation and of their propagation throughout the tidal waters of the earth.

The first part of the book is devoted to quite an extensive account of the history and development of the tidal science, after which the fundamental relations of the sun, moon and earth are given, followed by chapters on the making of tides, propagation of the tidal wave, tidal currents, mean level of the sea and range of the tides, effect of wind and atmospheric pressure on the tides, river tides, wind waves, seismic and cyclonic storm waves, tide tables and tide gauges and a chapter on the tides as a source of power.

The book is clearly and interestingly written and the reader, after starting any of the chapters, is compelled to proceed owing to many interesting statements made therein. This is probably because the raising and lowering of the sea twice in every day is ever an attractive subject and while the effect of the sun and moon upon tides is known in a general way, the subject-matter in the book clears up many doubtful points about it.

The back of the book is devoted to a number of useful tables and formula in reference to tides.

———o———

Gasoline Engine Ignition, by E. J. Williams. Size, 5 x 7. 9 chapters, 90 pages and 37 illustrations. Published by the Gas Engine Publishing Co., Cincinnati, Ohio. Price, $1.00.

This book treats of the electric ignition of gas and gasoline engines, whether for stationary, marine or automobile service. It is written especially for the user of a gasoline engine and explains the various features of make and break systems, jump spark systems, batteries, magnetos, dynamos, coils and spark plugs. There are numerous illustrations, including wiring diagrams and "kinks" and a chapter is added on horse power.

The book is written in a very simple manner and is intended for the novice who does not understand anything about electricity.

———o———

Twentieth Century Machine Shop Practice, by L. Elliott Brookes. Size, 5½ x 8. 600 pages, 415 illustrations, 57 tables. Published by Frederick J. Drake & Co., 350 Wabash Ave., Chicago. Price, $2.00.

This book is intended for the practical instruction of machinists, engineers and others who are connected with the use and operation of the machinery and machine tools in a modern machine shop. The first portion of the book is devoted to practical examples in arithmetic, decimal fractions, roots of numbers, algebraic signs and symbols, practical geometry and mensuration. Then follows a chapter on applied mechanics, which includes the lever, the wheel and pinion, the pulley, the wedge, the screw and the safety valve, friction belt pulleys and gear wheels, and chapters on the properties of steam, the indicator, horse power and electricity.

The latter part of the book is devoted to machine shop practice and includes the following subjects: Measuring devices, machinists' shop and machine tools, boring machines, boring mills, drill presses, gear cutting machines, grinding machines, lathes and milling machines, portable tools, plain and spiral indexing machines.

The book is written in a clear and simple manner and is profusely illustrated. The illustrations are well conceived and instructive and the many tables are particularly valuable for reference.

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### Camden Council.

EDITOR THE PRACTICAL ENGINEER:

The tenth anniversary of Camden Council, No. 3, A. O. S. E., was held on the 18th, in Post 5, G. A. R. Hall, the members and wives, sisters and mothers, mothers-in-law, children and grandchildren, all being present. The big fish, Hiram Trout, Supreme Chief of the Order, was present and gave a short talk, after which there were some amateur theatricals. Camden Council's Zobo Band made a hit in their overalls and jumpers, accompanied on the piano by Miss Winkler, the accomplished daughter of our first assistant. Refreshments were served and everyone present was given a zobo to blow themselves, which they did in all shapes, styles and tunes. The children were then loaded with oranges, bananas and peanuts, after which we adjourned.

Bro. Mark Rowland was chairman of the committee, while David B. Owen was master of ceremonies.

Yours very truly,

JOSEPH P. WHITLEY.

———o———

### Model Engineers' Second Meeting.

The American Society of Model Engineers held their second meeting at the Berkeley Lyceum, 19 West 44th St., New York, on Wednesday evening, May 2d. There was a good attendance and several new members were enrolled. Constitution and By-Laws were read and accepted.

Mr. Barclay gave a half hour's talk on "Shop Work with Lathe and Shop Tools." This was followed by a discussion on various subjects including the slide valve. Mr. Stoye gave a clear and concise explanation of the locomotive slide valve and the link motion.

Members present were requested to bring samples of their work for exhibition at the next meeting. Mr. Stoye promised to give a talk on small tools and their uses in model making, and to bring some tools for examination.

Anyone wishing to join this Society should correspond with the Secretary, Mr. W. E. Spon, 123 Liberty St., New York City.

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### How a Cranky Injector was Cured.

EDITOR THE PRACTICAL ENGINEER:

My injector was connected to the only feed pipe in the factory, with the result that it generally broke when anybody drew water elsewhere. I put a float cock in a barrel and now I have plenty of water and the injector never breaks. This has helped me and may help others who have the same trouble.

Brooklyn, N. Y. A. C. A.

# TRADE NOTES

**EDITED BY THE ADVERTISING MANAGER**

Robbins Conveying Belt Co., Park Row Bldg., New York, have issued a new bulletin No. 14, which is devoted exclusively to their conveying and elevating machinery for handling sand, stone, concrete materials and excavated earth and rock. It will interest those who are engaged in this class of work.

The Ohmen Engine Works, 15th and Utah Streets, San Francisco, Cal., desire catalogues of all kinds of power plant equipment and supplies.

Now, while the heating system is idle, is a good time to investigate the McKnight Receiver and Oil Separator. Write for descriptive circular to Walter J. McKnight, 179 Washington St., Buffalo, N. Y.

One of the best engine catalogues that nas recently come to our notice has just been issued by the Murray Iron Works, Burlington, Iowa. It is devoted to Murray Corliss engines and Murray boilers, all of which are comprehensively described and attractively illustrated with large full-page cuts, showing complete plants and single units of various types and sizes and also many detail cuts, showing the different parts and explaining the distinctive features of each. This catalogue will prove a valuable addition to the library of any engineer or other person interested in the selection of prime movers.

The Allis-Chalmers Co. have opened offices at 906 Broadway, Oakland, Cal., and also in the Atlas Bldg., 602 Mission St., "New" San Francisco.

The new method of lubricating Reeves engines affords perfect separation of the water seepage of the stuffing boxes from the guide and crank chamber, which is said to greatly improve the lubricating qualities of the oil and also renders it possible to use the same oil over and over again. This is only one of the distinctive features of these engines which have become so popular of late. A catalogue describing them in detail will be mailed to those who are interested.

A little booklet of genuine interest to every engineer or user of lubricants has just been issued by the Philadelphia Lubricator and Mfg. Co. It treats of various methods of applying lubricants rather than of the lubricant itself, and describes conditions resulting from the use of improper applications displaying an intricate knowledge of the science of lubrication and advancing many ideas which we have not previously seen in print. Any engineer can profit by a careful reading of this little booklet, a copy of which will be sent to any reader of THE PRACTICAL ENGINEER sending his name and address to The Philadelphia Lubricator and Mfg. Co., 1525 Land Title Bldg., Philadelphia.

The manufacturer of the Selden and Zena packings, Mr. Randolph Brandt, has moved his office from 38 Cortlandt St., where he was located for over twenty years, to 70 Cortlandt St. At the same time Mr. Brandt has moved his factory to larger quarters. With new and increased facilities, these well-known packings will be placed in the hands of engineers in better shape than ever.

The Homestead Valve Mfg. Co., of Pittsburg, Pa., advise us that they are turning out more valves than at any time in the history of their business and that the prospects for future business are excellent. It is interesting to note how these well-known old valves have stood the test of time and have grown in popularity.

Fairbanks, Morse & Co., San Francisco, Cal., now occupy temporary headquarters at 969 Broadway, Oakland, California, until they are able to return to their permanent location in San Francisco, where they were recently burnt out in the disastrous conflagration following the earthquake.

Spon & Chamberlain, 123 Liberty St., New York, have just issued a new book on Mechanical Draft, by J. H. Kenealy. A circular giving a complete synopsis of its contents will be mailed to any reader upon request.

John R. Livezey, 1936 Sansom St., Philadelphia, has issued a fine new catalogue describing his method of applying Nonpareil Cork in cold storage insulation. It contains a number of illustrations which show exactly how the cork is applied and held in place. These illustrations are more instructive than any amount of explanation in type. Mr. Livezey is an expert on cold storage insulation and has made many notable successes. His knowledge of cork and its many applications to cold storage insulation is probably unequalled. Every reader who has to do with cold storage for any purpose should write for a copy of his new catalogue.

After having been for over a quarter of a century in their former location, Benjamin F. Kelley & Son, manufacturers of the Berryman Feed-Water Heater and Purifier, have removed to 120-122 Liberty St., New York, where they will have more desirable quarters and will be glad to see any of their friends and patrons.

If you want a fan, a circulating or exhaust fan for any purpose, write for the catalogue of Joseph Carr, 132 N. Seventh St., Philadelphia.

The business formerly carried on under the name of Wilkinson & Hackett, at 428 Temple Court, New York City, has been dissolved by mutual consent, Mr. J. B. Hackett having taken over the agency for New England Roller Grate Co., which includes New England roller grates, shaking, dumping and circular grates. Mr. Hackett will continue at the same address.

**Wanted** A few good and competent engineers along the Ohio, Mississippi and Kanawah Rivers, to sell the best thing on earth. This can be done after working hours and between times. Address, J. L. TILLMAN, 521 Colburn Street, Toledo, Ohio.

**Wanted** Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address FRANCE PACKING Co., Tacony, Phila., Pa.

**PATENTS** Watson E. Coleman, Patent Attorney, Washington, D. C. Advice free. Terms low. Highest ref.

**PATENTS Procured** ISEDORE S. PRENNER, E.E. Attorney-at-Law, Solicitor of Patents, Consulting Engineer, Law, Patent and Engineering Cases. Room 1108 Betz Building, Philadelphia.

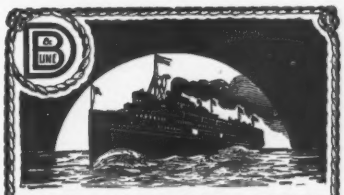
**PATENTS** PROMPTLY SECURED. Highest references from prominent manufacturers. Write for Inventors' Hand-Book, SHEPHERD & PARKER, 186 Deitz Building, Washington, D. C.

**Salesman** to sell manufacturing and foundry trade in Eastern Pennsylvania. Must not be over thirty. One with some experience preferred. State full particulars and salary expected. Address A. B. Care Practical Engineer, 46 No. 12th St., Philadelphia.

**For Sale** A Nadig Horizontal Slide Valve engine, capable of developing from 20 to 3o horse power. Cost $250, and has never been used. Will sell It complete for $150 f.o.b. care Allentown, Pa. Address H. R. Lawfer & Co., Allentown, Pa.

**For Sale** cheap for cash. Robertson-Thompson Improved steam engine indicator, and Victor reducing wheel, both new only used once. Sold for want of use. Address A. K. Vradenburgh, 124 Garden St., Poughkeepsie. N. Y.

**For Sale a 70 ton Ice Plant.**
A seventy ton ice plant complete in first class condition, consisting of two 35 ton York machines, 3-150 H. P. Heine Boilers, 150 pounds pressure, 14 x 14 x 14 air compressor, engine and dynamo, 5 pumps, 2 heaters, 1 Wheeler condenser, purifiers, tanks, ice coils and cans. Plant now in operation and will be sold cheap as it must be moved off the ground by October. France Packing Company, Tacony, Penna.



**THE WATER WAY**
**BETWEEN**
**Buffalo and Detroit**

The D. & B. Line Steamers leave Buffalo daily at 5:30 p.m. (eastern time) and Detroit week days at 5:00 p.m., Sundays at 4:00 p.m. (central time) reaching their destination the next morning. Direct connections with early morning trains. Lowest rates and superior service to all points west.

**Rail Tickets Available on Steamers**

All classes of tickets sold reading via Michigan Central, Wabash and Grand Trunk Railways between Buffalo and Detroit, in either direction, will be accepted for transportation on D. & B. Line Steamers. Send 2 cent stamp for illustrated pamphlet. Address
**A. A. SCHANTZ, G.S. & P.T.M., Detroit, Mich.**
**Detroit & Buffalo Steamboat Co.**

The Henry Greenwald Company, 250 South Eleventh St., Philadelphia, are doing good work in furnishing engineers to fill vacant positions and in procuring employment for capable and trustworthy engineers. During the past two or three years they have filled hundreds of engineering positions, among which were some of the most responsible positions in Philadelphia and vicinity. This Company is not to be classed with the ordinary employment agency; their methods are entirely commendable and they have rendered efficient and highly valuable service to both employer and employee. Write for their booklet called "Good Words from Good People."

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The Lunkenheimer Company, of Cincinnati, Ohio, have opened a well-equipped branch store at 66-68 Fulton Street, New York City.

Previous to the above date, the Company maintained a suite of offices in the Havemeyer Building, 26 Cortlandt Street, through which offices the export trade of the concern was transacted.

While the trade in New York City and Eastern States were able to a great extent to procure Lunkenheimer engineering appliances from the various supply houses, nevertheless, the increased demand for these well-known specialties necessitated the opening of a branch from which the supply houses and trade in the New York territory could be instantly accommodated.

The same courteous attention charasteristic of the Company will be found to prevail in their new establishment. Being grateful for the patronage of the Eastern trade, it is their endeavor to further accommodate the trade by prompt attention to all orders, to do which they have gone to quite an expense by opening their branch store and supplying same with a large and complete line of their many specialties.

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The Wetzel Mechanical Stoker Company, of 147 East State St., Trenton, N. J., have received orders during the past month for Wetzel Stokers, as follows: 3 stokers, 150 horse power each, for A. Booth & Co., Detroit, Mich.; 3 stokers, 150 horse power each, The Starr Engineering Co., for New York City; 4 stokers, 300 horse power each, for New York and Penna. Co., Johnsonburg, Pa.

Three Wetzel Stokers were recently installed at the Hestonville Ice Plant, 52d and Jefferson Streets, Philadelphia, where they are burning soft coal without a particle of black smoke and in addition to increasing the capacity of the plant are showing a decided saving in both fuel and labor. The chief engineer and his assistants commend them very highly. The Wetzel Co. recently issued a large new catalogue which they will mail to anyone interested.

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The Otis Feed-Water Heater and Purifier is shown to marked advantage in a small but interesting catalogue published by the Stewart Heater Co., 11 Norfolk Ave., Buffalo, N. Y. One of the great advantages claimed for the Otis heater is its special provision for separating and eliminating oil and grease, all of which is comprehensively explained in the catalogue. Another interesting feature of the catalogue is a table giving sizes, capacities, heating surface, diameter of feed pipe, shipping weights and prices, all of which is invaluable to the man who is contemplating the purchase of a new heater. A copy of this catalogue will be mailed upon request.

---

The design of the blades or cutters on the Ruggle's "Perfection" Flue Cleaner is such that the edges are always in direct contact with the inside surface of the flue and they cut both going and coming. The set of the blades gives them a tendency to work in closer all the time, thus making themselves sharpening, and being flexible, they will override imperfections in the tubes, such as blisters or welds. On account of the long shearing cut of the knives, this cleaner is said to do its work with the greatest ease. They are manufactured by the Scully Steel and Iron Company, corner of Holsted, Fulton and Wayman Sts., Chicago, Ill. A circular giving sizes, prices, etc., will be mailed upon request.

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During the last month or six weeks, the Wilkinson Mfg. Co., of Bridgeport, Montgomery County, Pa., have closed orders for 3500 horse power Wilkinson Automatic Stokers for the Waldorf-Astoria Hotel, New York City; 4000 horse power of stokers for the New Plaza Hotel, New York City; 2000 horse power of stokers for the Jacob Ruppert Brewery, New York City; 800 horse power of stokers for the Firth-Sterling Steel Co., Pittsburg; 400 horse power of stokers for the Elk Tanning Company, Ridgway, Pa. The large shops of the Wilkinson Company are working to the limit of their capacity to get out these and other large orders. At no time in the history of mechanical stokers has the demand for them been so large. It seems that many engineers are just beginning to realize the advantages of stokers.

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Mr. M. J. Stewart, Chief Engineer City Hospital, St. Louis, Mo., recently made a test of a Demon water-tube boiler cleaner and in his report to the chairman of the City Hall Commissioner wrote as follows: "I have cleaned one 250 horse power Heine boiler with the Demon cleaner and found that it absolutely cleaned all the scale from the tubes and left them the same as new. I have never seen its equal as a boiler cleaner." The Demon is the new water-tube cleaner brought out several months ago by the General Specialty Co., 75 Carroll St., Buffalo, N. Y. It is said to be highly successful.


**GRAPHO**
**SOMETHING NEW**
A new preparation for enriching oils.
Will suspend in oil.
No more Hot Journals.
Engineers who have tried same claim it to be the best yet.
**SEND FOR SAMPLE**
A trial will convince you
**AGENTS WANTED**
**GRAPHO MFG. CO.**
Cor. Frank and Commercial Sts.
ROCHESTER, N. Y.

**F. A. Genth, Jr.**
**Analytical and Consulting Chemist**
222 WALNUT STREET
**Telephone** **Philadelphia**

**NEW EDITION**
**Care and Management of**
**Electric Power Plants**
**By NORMAM H. SCHNEIDER**
thoroughly revised and enlarged, with many new diagrams, tables and 137 new illustrations.
A practical book for the practical man, containing a fund of valuable information for those who have to do with Electric plants.
Among others there are chapters on
**Storage Batteries**
**Standard Wiring**
**Switchboards and Instruments**
**Incandescent Lamp Testing**
294 Pages 203 Illustrations
Handsome Full Limp Leather, - $2.50
Cloth, - - - - - - $1.50
**Spon & Chamberlain**
123 P. E. Liberty St., New York

**The Smith Pipe Clamp**

**Stops The Leak Every Time**
A complete set for every size of pipe in your plant will save many a dollar. Quickly applied while pressure is on the pipe WE GUARANTEE TO STOP THE LEAK. Steel or brass, all sizes, ¼-inch to 20-inch. No trouble to send further information.
**W. CLIFFORD SMITH**
138 N. SIXTH STREET
PHILA., PA., U. S. A.

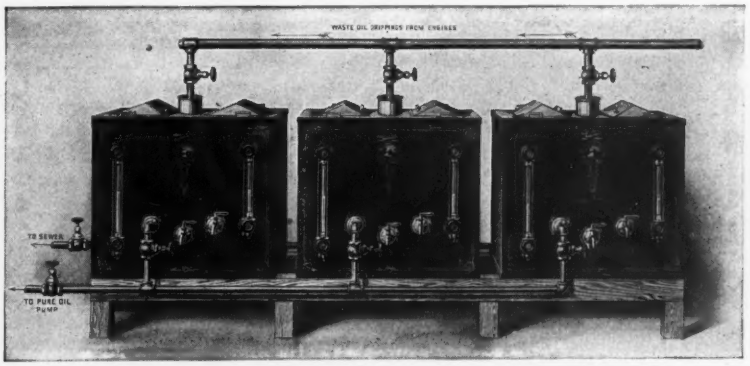
# "Unit Type" Oil Filters

are the results of 15 years' experience in making over 20,000 Oil Filters, and are the most modern filters on the market today. Our filters have a world-wide reputation, are used in 29 countries, and have been officially adopted by 10 governments. Our "Unit" Filter is 42 inches long, 3 feet high and 28 inches wide, with a filtering capacity of from 175 to 225 gallons in 24 hours. Filter can be used with or without an oiling system, and is so constructed that ANY KIND of filtering material can be used and is GUARANTEED to clean and purify the thinnest as well as the heaviest grades of lubricating oil—such as cylinder, crank case, lard oil, etc. Any number of "Units" can be operated together or separately, as desired. Whenever the power plant increases, additional "Units" can be installed and connected with those in operation; thus the oiling system increases in proportion to the growth of the plant.

**JUST A FEW "UNIT" USERS**

Philadelphia Rapid Transit Co., Phila., Pa. (10)
Ashland Steel Co., Ashland, Ky. (3)
Calumet & Hecla Mining Co., Calumet, Mich. (3)
Rockefeller Bldg., Cleveland, Ohio (2)
Rome Brass & Copper Co., Rome, N. Y. (2)
Dayton Lighting Co., Dayton, Ohio (2)
Jacob Ruppert Brewing Co., New York, N. Y. (2)
Mutual Life Insurance Co., New York, N. Y. (2)
Alabama Portland Cement Co., Demopolis, Ala.
Niagara Construction Co., Niagara Falls, N. Y.
Olympia Cotton Mills, Columbia, S. C.
Carnegie Natural Gas Co., Waynesburg, Pa.
Ardoyne Plantation, Ellendale, La.
Goodyear Tire & Rubber Co., Akron, Ohio
Dartmouth Mfg. Corporation, New Bedford, Mass.
Indiana Railway Co., South Bend, Ind.
Manual Training High School, Kansas City, Mo.
Somerset Coal Co., Pine Hill, Pa.
Athens Electric Railway Co., Athens, Ga.
The John Bromley's Lace Mill, Philadelphia, Pa.
Headley Chocolate Co., Baltimore, Md.
Singer Manufacturing Co., St. Johns, Canada.
St. Louis Portland Cement Co., St. Louis, Mo.
The City of Evansville, Evansville, Ind.
The Muncie & Portland Traction Co., Portland, Ind.
Selma Lighting Co., Selma, Ala.
Uncasville Mfg. Co., Uncasville, Conn.
De Lamar's Copper Refining Co., Chrome, N. J.
Land Title Building, Philadelphia, Pa.
The Cleveland Frog & Crossing Co., Cleveland, O.
Post Office Department, Washington, D. C.
Kosmos Portland Cement Co., Kosmosdale, Ky.
American Brass Co., Ansonia, Conn.
Peerless Rubber Mfg. Co., New Durham, N. J.
Baldwin Locomotive Works, Philadelphia, Pa.

The Philadelphia Rapid Transit Company, operating eight of the most modern power plants in the United States, after examining all of the leading makes of filters on the market today, selected 6 of our "Units" for use in connection with 33,000 h. p. steam turbines installed in their new plant. These have given such good satisfaction that they have just placed an additional order for 4 more "Units".




**Three "Units" Connected and Operated as One Filter.**

The Calumet and Hecla Copper Mining Co, the largest copper mining corporation in the world, have recently, after careful examination, placed their order with us for 3 "Units" for their new power plant—a power house embodying the latest and most improved machinery. It might be well to add that this firm has purchased 20 oil filters from us during the last 12 years, which speaks for itself.

Another notable equipment was an installation of 2 "Units" for the new office building recently erected in Cleveland, Ohio, by John D. Rockefeller of the Standard Oil Co (This firm has 73 of our filters in use in their own pumping stations.)

The Baldwin Locomotive Works, known throughout the entire world as users of the latest and most improved machinery, have just ordered one "Unit" to be installed in their new power house.

Every engineer, mechanical engineer, consulting engineer—in fact, anyone coming in contact with power plants, should have a copy of our new 48-page catalogue—the finest issued by an oil filter firm. It contains a full description of our "Unit" Filter, also the "Cross" American and Warden Oil Filters and the Burt and Standard Exhaust Heads.

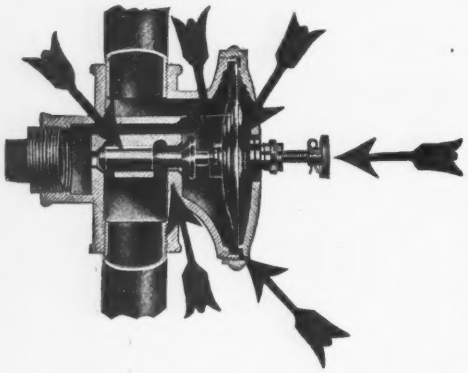
**The Burt Mfg. Co.** Largest Manufacturers of Oil Filters in the World. 204 Main Street, AKRON, OHIO, U. S. A.

Also Supplied by Engine Builders, Dealers, and Power Contractors

Carried in stock by Shelby & Co., 66 Leonard Street, London, E. C., England, Sole Agents for Great Britian.

A novel method of bringing out the good points of the Dunham Steam Trap has been embodied in the illustration here shown. It makes plain to those who have not studied this little device, the fundamental plan upon which it is built, and the principal features that it embodies.

Reference is made first to the arrow indicating the thickness of the phosphor-bronze



walls containing the seats. Ample stock is provided here so that after years of service the valve can be reseated, and the trap made as good as new.

The point of the arrow at the lower right-hand corner is in contact with a specially prepared gasket, just fitting a recess in the cap, which prevents its spreading or readily coming out. This comes into contact with the face of the trap flange and forms a perfectly tight joint by simply screwing the cap up by hand.

The adjustment is shown by the horizontal arrow. It is composed of an adjusting knob, split cotter pin and combination stuffing box and lock nut, which are placed on the threaded stem of the expansion disc. The disc swings on this axis in the space provided for it—it is the motor which exerts a pressure upon the valve stem of 25 pounds, and a pulling force of 14 pounds under opposite conditions.

The fifth and sixth arrows indicate the large partially-balanced valve, with its two faces that fit corresponding seats in the body. This valve is connected directly to the motive force without levers, hinges or frictional joints of any description, and its movements are governed by water and steam.

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The Mechanical Electrical Construction Co. have removed to 1609-11 Camac St., Philadelphia, where they have much larger quarters than formerly.

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"Link Motions, Valves and Valve Setting" is the title of an interesting book which H. B. Underwood & Co., 1025 Hamilton St., Philadelphia, are sending out to engineers. It describes the Locomotive Link Motion in detail; the setting of slide valves and piston valves; with numerous illustrations, and also gives a great amount of other information concerning valve movements, etc., of more especial value to locomotive men.

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The Sims open type of feed-water heater is described in detail in a special circular issued by the manufacturers. The construction of this filter is sufficiently novel to interest engineers. For copy of circular, address The Sims Co , Twentieth Street, Erie, Pa.

---

**Auctioneering Inventions by Mail.**

Valuable inventions often lie dormant, or are stolen, because inventors lack the time, opportunity or business ability and acquaintance which enable them to dispose of their inventions profitably.

Likewise, there are scores of manufacturers and capitalists who would be glad to acquire the right to manufacture and market useful devices if the latter were brought to their notice.

Both lose from lack of communication. The inventor allows his invention to slumber or unwisely disposes of an interest to persons who lack sufficient capital or business ability to exploit the invention properly. The manufacturer or inventor, on the other hand, often hunts in vain for a suitable article to introduce, or, too late, sees it acquired by incompetent rivals, whose only object may be to exploit it sufficiently to be able to resell it.

What is needed is advertising (auctioneering by mail) by means of which the inventor can find the right buyer and the buyer the invention he wants.

The Geo. H. Gibson Co., Advertising Engineers, Park Row Building, New York City, have recently taken this subject up. This concern acts as commission agent in the selling of inventions and uses personal representation and correspondence in bringing about a sale.

Their clients' inventions are presented in a bulletin, entitled, "Engineering and Manufacturing," which has just come to hand and which contains, in addition to descriptions of several new inventions, articles of interest to manufacturers and inventors.

---

A new catalogue, fresh from the press, forcefully written and handsomely illustrated with unusually good cuts of many prominent buildings, industrial establishments and power plants which are under the protection of the "Monarch" has just been received from the Consolidated Engine Stop Co., 132 East 12th St., New York City. It relates to Monarch Engine Stop and Speed Limit System and is an interesting piece of literature which should be read by every engineer having charge of a power plant where it is desirable to avoid shutdowns and accidents to life and property. The Company will send a copy to any reader of THE PRACTICAL ENGINEER upon request.

---

The White Star continuous oiling system and also the White Star oil filter are instructively and entertainingly described in a finely illustrated new booklet issued by Pittsburg Gauge and Supply Co., Pittsburg, Pa. Ask for booklet F.

---

Mechanical Rubber Goods have become such an important and indispensable factor in engineering practice that it is refreshing to receive a manufacturer's catalogue which really contains the kind of information that engineers so frequently require. Many catalogues show pictures, but few of them get down to the meat of the subject and give the engineer the facts that he is so often in need of. They abound with glittering generalities but neglect the detail that would aid most in the practical application of the products that they are intended to exploit.

We have received a new catalogue just issued

by the Quaker City Rubber Co., 409 Market St., Philadelphia, which is a distinct and welcome reversal of the usual form. It is 6 x 9 inches in size, with 80 pages, every one of which is filled with instructive illustrations and detailed information of genuine value to the purchaser and user of the goods shown. It describes a very complete line of Packings, Hose, Gaskets, Rubber Belting, etc., and gives formulas, rules, methods of applications and tables of real value. Every user of mechanical rubber goods should send for a copy before they are all gone.

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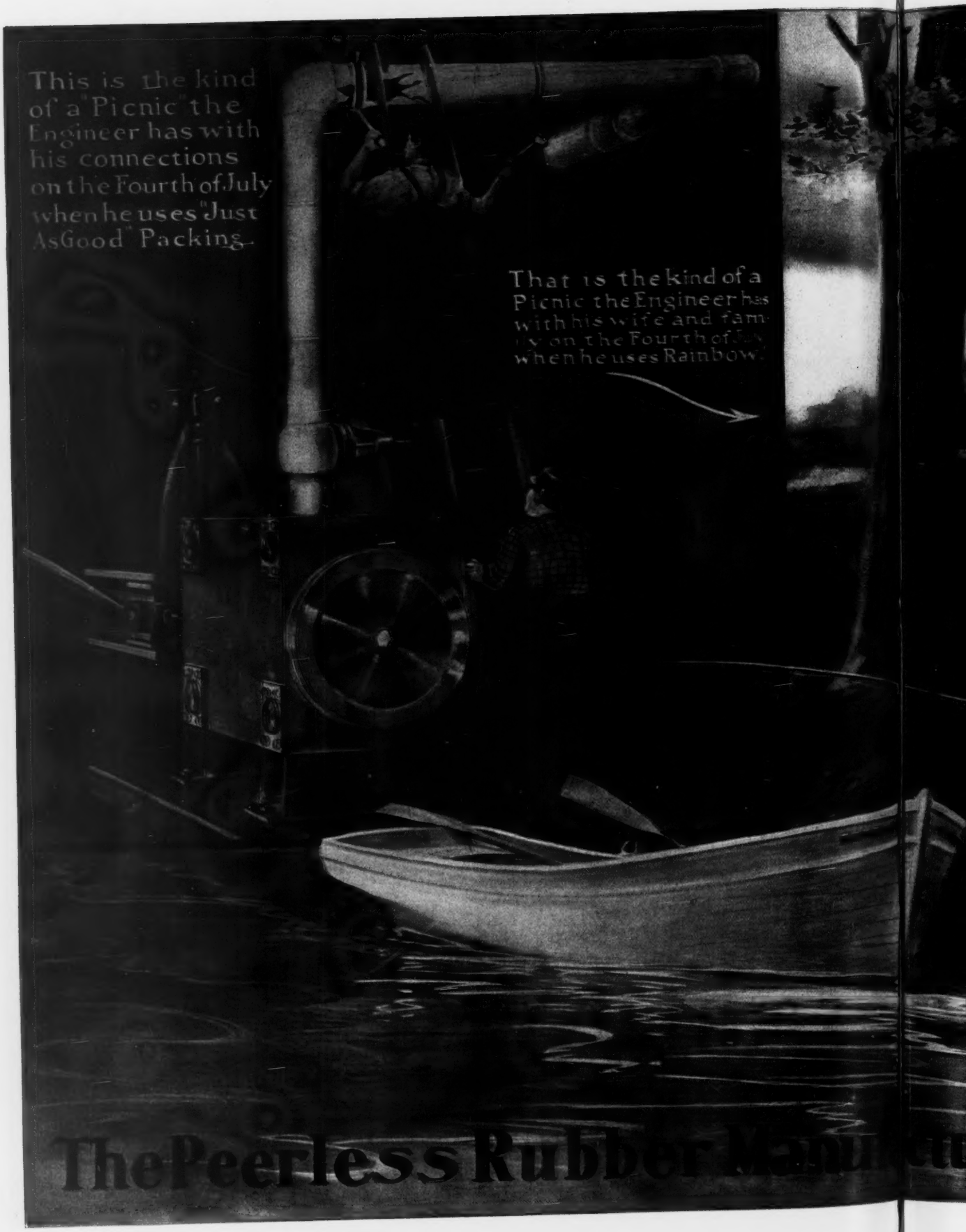
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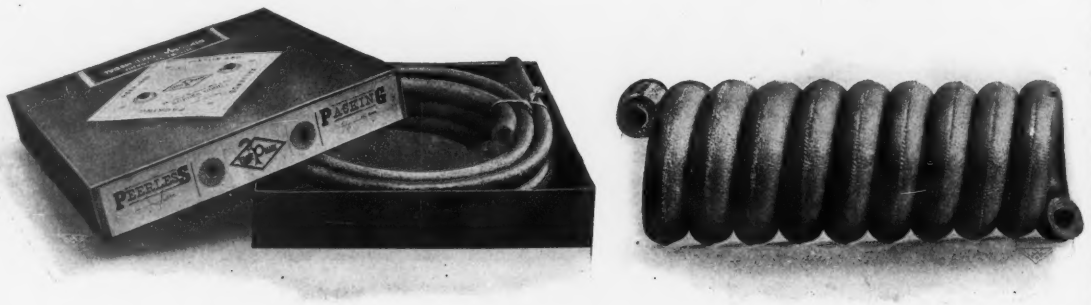


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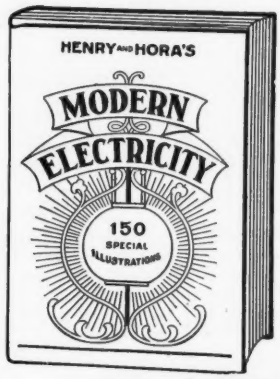


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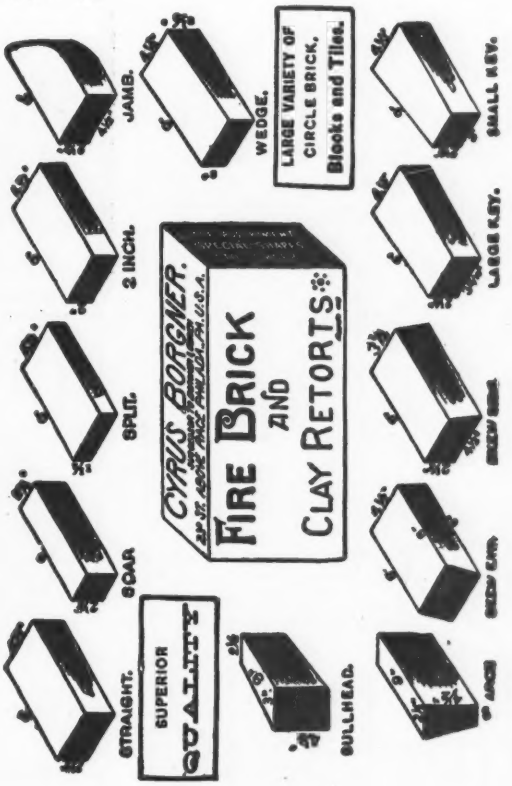




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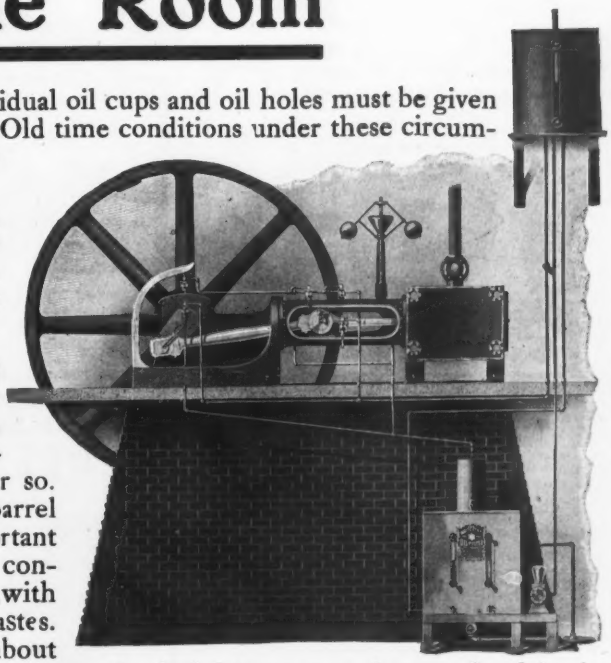

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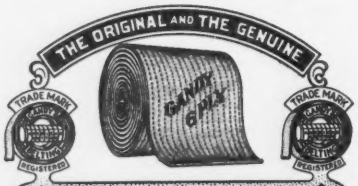


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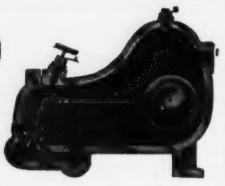

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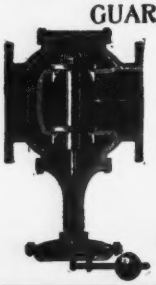

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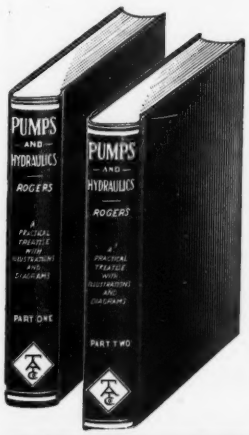


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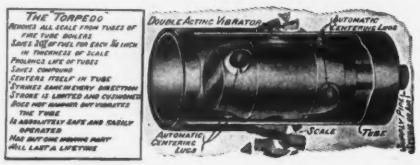
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REMOVES ALL SCALE FROM TUBES OF FIRE TUBE BOILERS
SAVES 20% OF FUEL FOR EACH 1/8 INCH IN THICKNESS OF SCALE
PROLONGS LIFE OF TUBES
SAVES EXPENSE
CENTERS ITSELF IN TUBE
STROKES SAME IN EVERY DIRECTION
STROKE IS LIMITED AND CUSHIONED
DOES NOT HAMMER BUT VIBRATES
THE TUBE
IS ABSOLUTELY SAFE AND EASILY OPERATED
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WILL LAST A LIFETIME
DOUBLE ACTING VIBRATOR
AUTOMATIC CENTERING LUGS
AUTOMATIC CENTERING LUGS
SCALE
TUBE

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The popularity of the "Torpedo" fire tube scale remover grows each day. Hundreds of these machines are in use in every part of the continent. Every plant using water tube boilers must have a cleaner, so why should not every plant with fire tube boilers also have a device to clean them?

It should. The scale is there just the same, but don't think just because you can't see it that it isn't to be found. The "Torpedo" will find it and shake it off in mighty short order, if you will only give it a chance.

Bear in mind that the "Torpedo" is the only machine made that removes the scale on the vibration principle and not the dangerous and obsolete "hammer" idea. Boiler tubes were never made to hammer the life out of them.

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This cleaner is the latest and most advanced type of all water tube cleaners. It employs a principle for using hydrostatic pressure not to be found in any other cleaner in the world. You know when you have a large piston area and a good pressure to drive that piston an immense force is developed.

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The cutters are made from solid tool steel, hardened, and they are set out positively to the inside diameter of a clean tube, so that they must remove all the scale right down to the iron, for the operator cannot force the "Demon" over scale. This feature is unique in the "Demon" and renders it a most valuable device, especially in the hands of unskilled operators.

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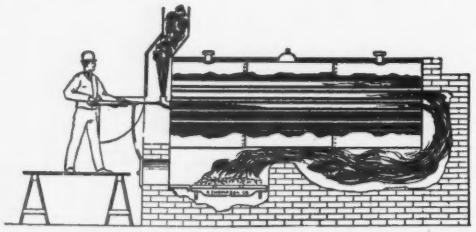

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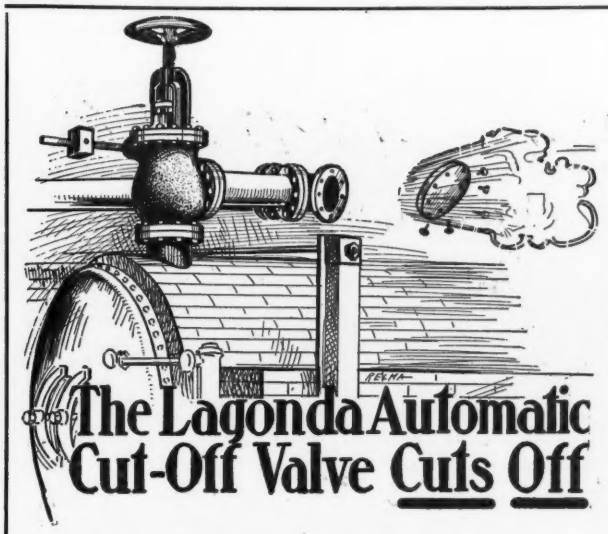

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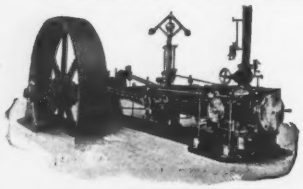

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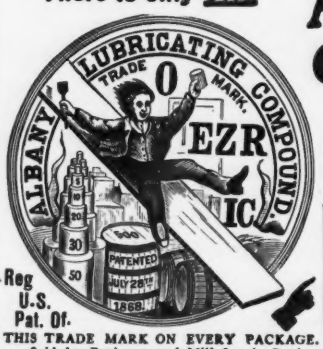


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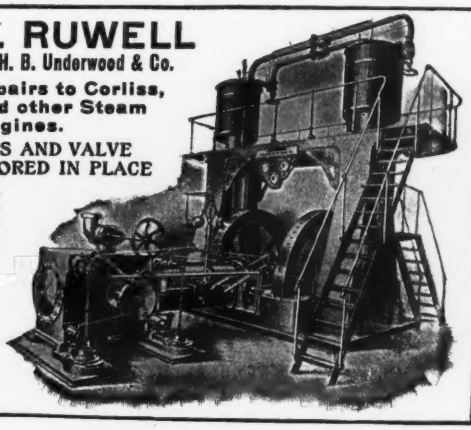

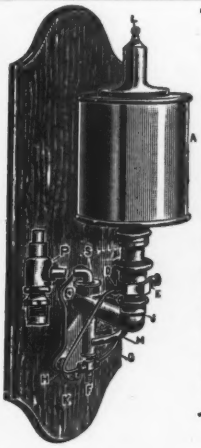

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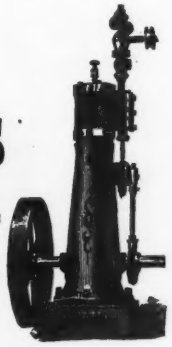

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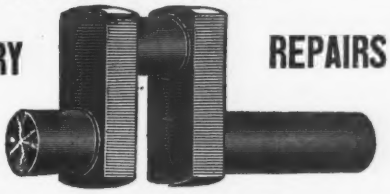

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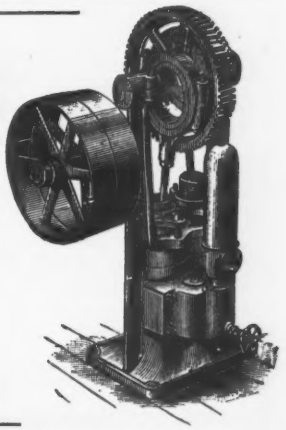

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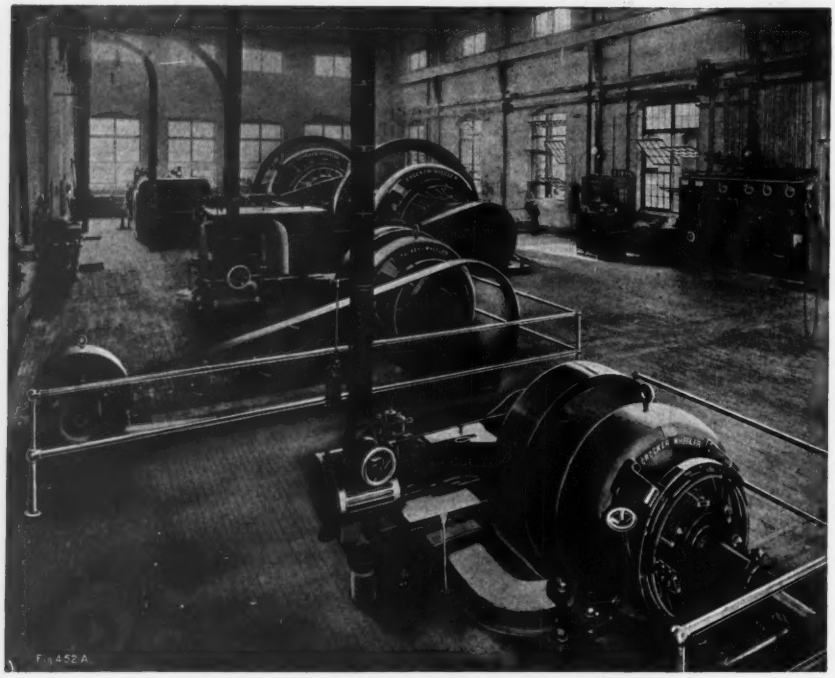

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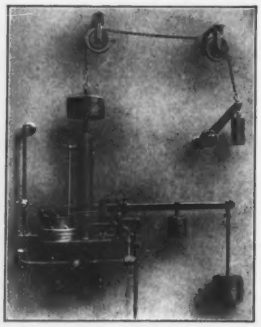

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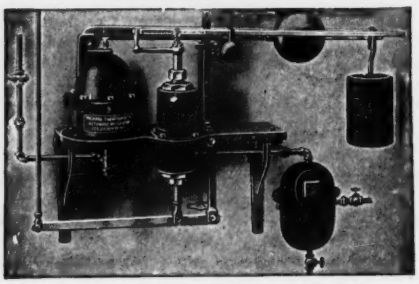

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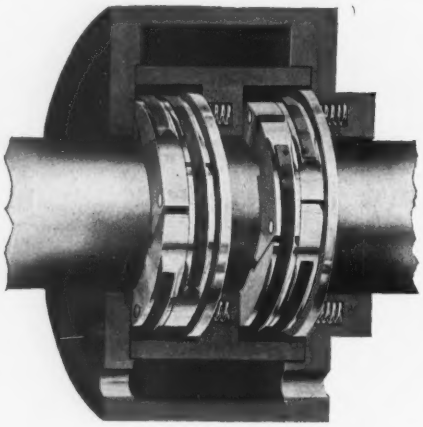

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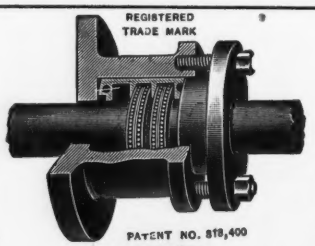


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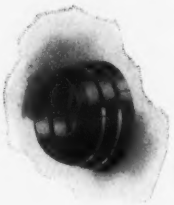

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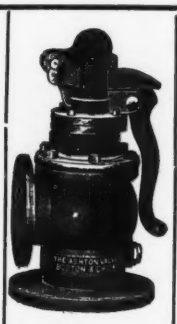

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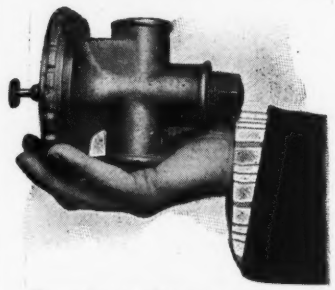

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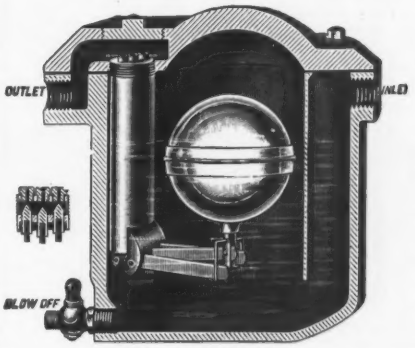


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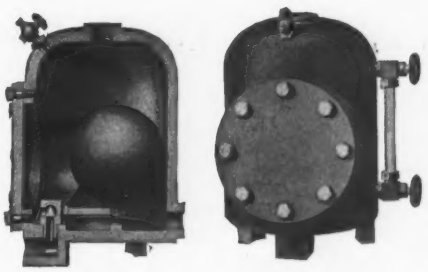

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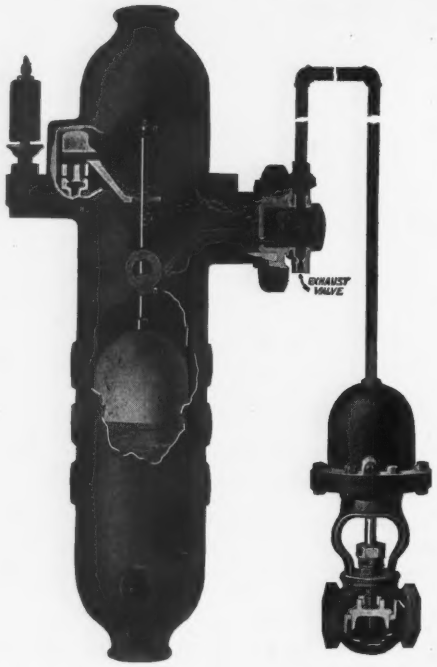


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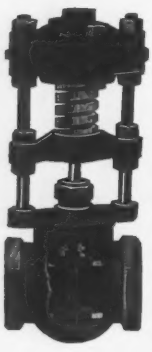

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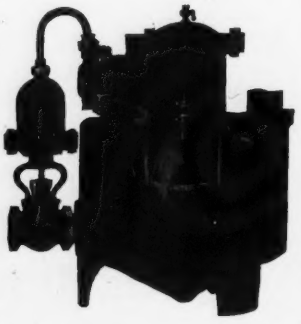

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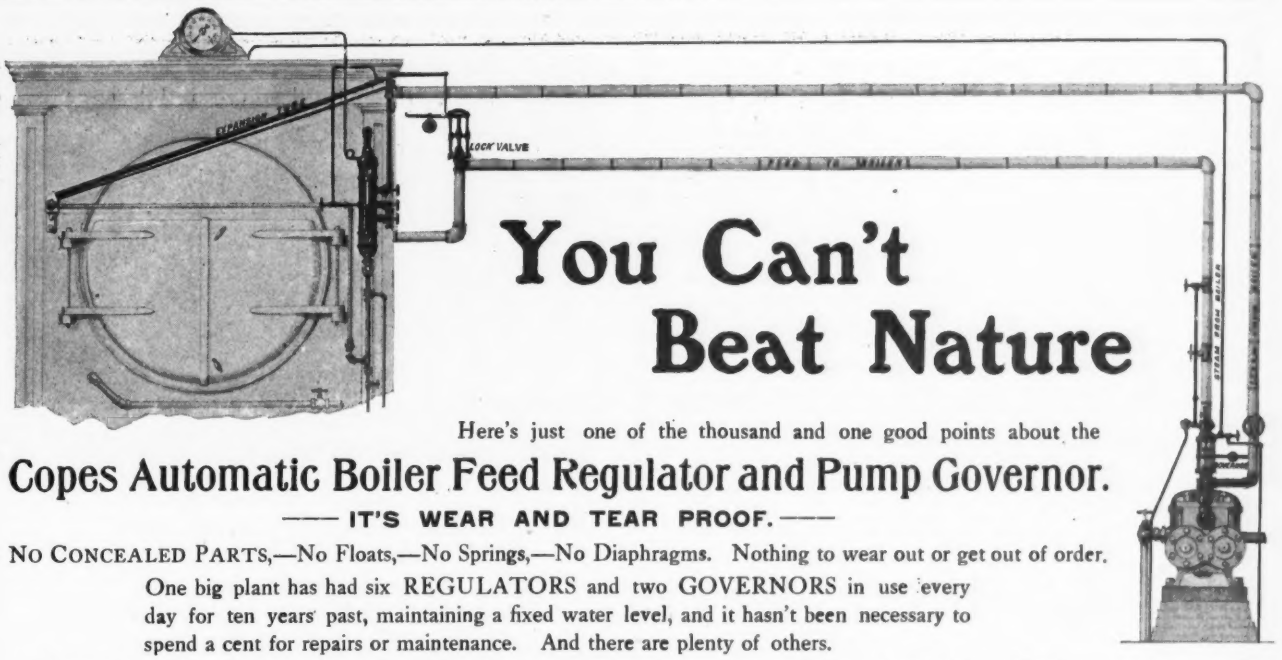


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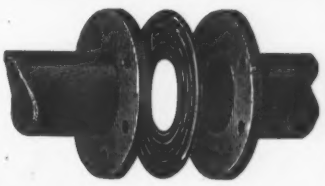

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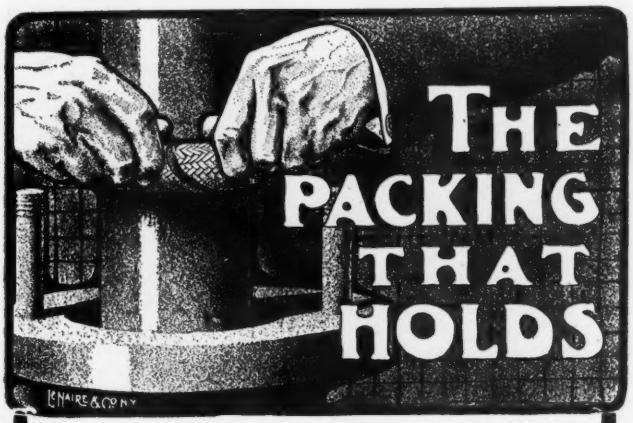


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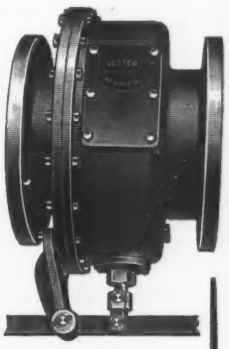

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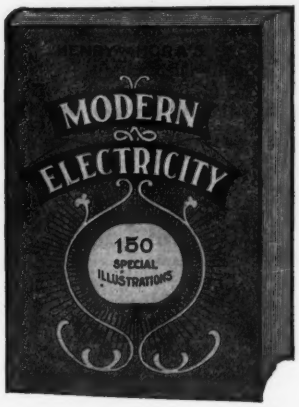


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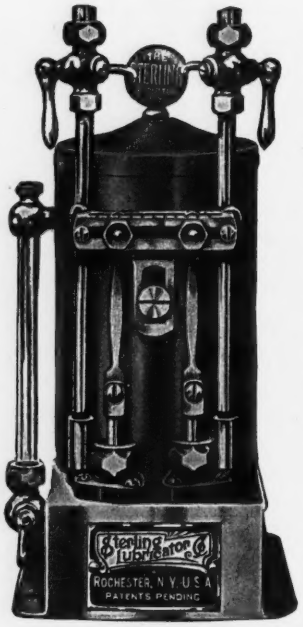


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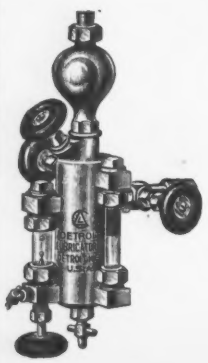

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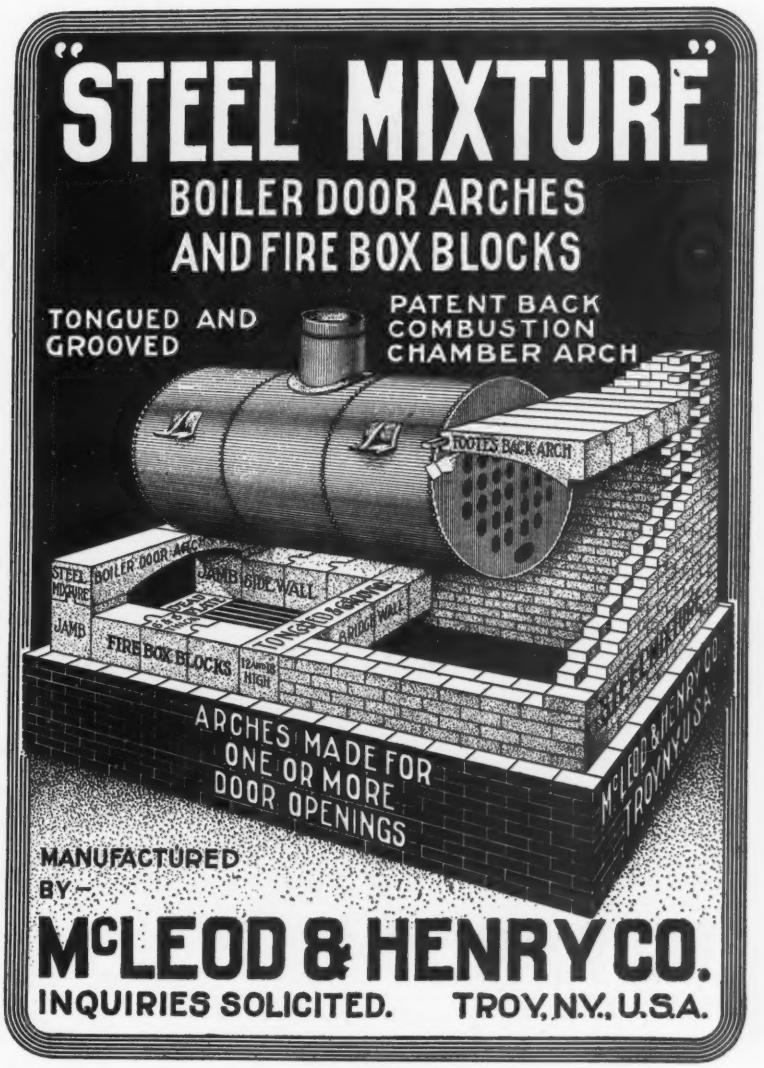


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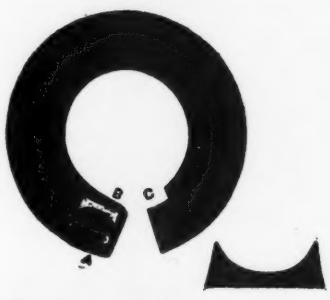


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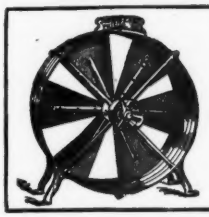

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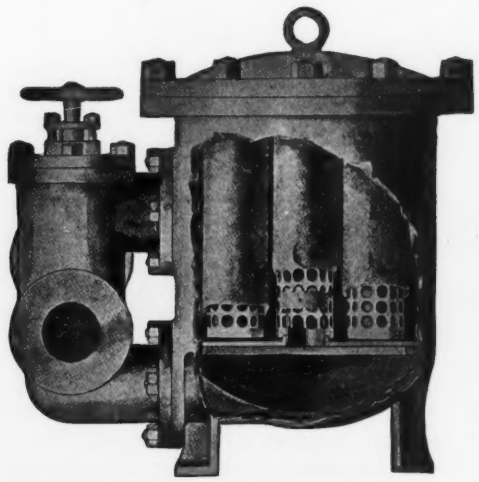

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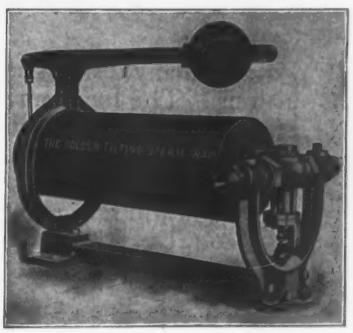
No Floats No Valves No Buckets inside of traps; all working parts outside. — Compensating Roller Bearing in lever; hence NO SHOCK OR JAR.



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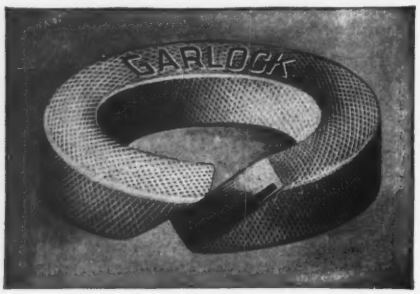
Every engineer knows that an inferior quality of packing is dear at any price for the small saving in first cost of packing will not compensate for increased friction or a scored rod.




**STYLE No. 200**

For superheated and high pressure steam, high speed engines, gas engines and for rods running in oil, grease or acid also for expansion joints. The highest grade of fibrous packing in the world.

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are made of the best material that can be procured. We make special packings for every kind of service. Two styles are shown herewith, many others in our catalogue. We also make the best Metallic Packing.

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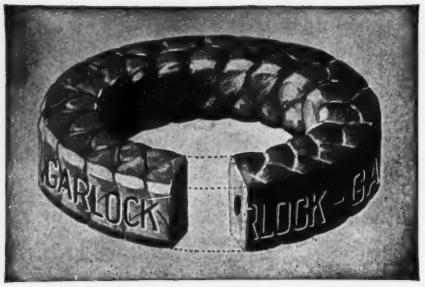


**STYLE No. 99**

For hydraulic work, cold water pistons and plungers or cold water pumps, elevators, accumulators, cold oil brine, etc. This style is known as Garlock Water Proof Hydraulic. Instruction for using sent with each package.

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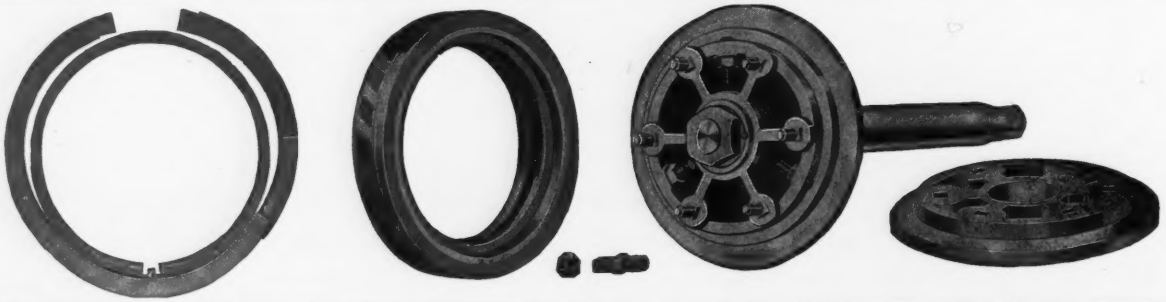

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Possess many distinct advantages which make them vastly superior to any other engine pistons. The inner spring ring, shown in cut, expands the interlocking packing ring just enough to insure a steam-tight fit without undue pressure against the cylinder walls. It automatically adapts itself to variations in temperature or unevenness in cylinder. It insures a perfect fit with a minimum of friction. It never gets out of order, never needs adjustment, and will save enough in fuel to repay its cost many times.

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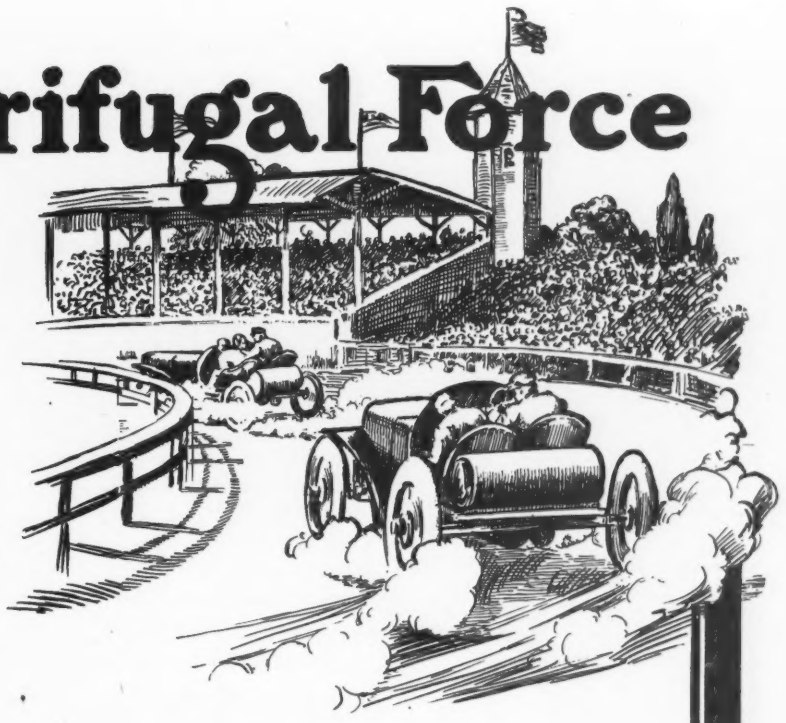
**Demonstrated as the Auto Swings Around a Curve---**

The illustration resembles the principle by which the Steam is freed from the water, in the invincible



## Swartwout Vertical Steam Separator

**—the Separator without fault.**

As the Steam enters the Separator it comes in contact with the helical worm—causing a violent rotation, and the water is thrown violently to the peripheral walls of the Separator, whilst the steam, freed from water, passes through the center tube into the engine cylinder—hence this Separator, on the principle of centrifugal force separates most effectively.

Our "How a good Separator Works" Booklet is both interesting and instructive—you should get it. If looking for a good Exhaust Head—the Swartwout Cast Iron Exhaust Head is worth considering—users say it is the best—and they ought to know. We solicit enquiries.

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You can save dollars in operating your power plant, by installing

# The Patterson - Berryman Feed Water Heater and Purifier

You can economize still further by using

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They will supply your boilers with pure water heated to the highest temperature obtainable by means of exhaust steam, without back pressure.

We are so confident that you will be pleased with the results obtained by the use of these two machines, that we are willing to ship either or both of them to you on trial with the understanding that they may be returned at our expense should they prove unsatisfactory.

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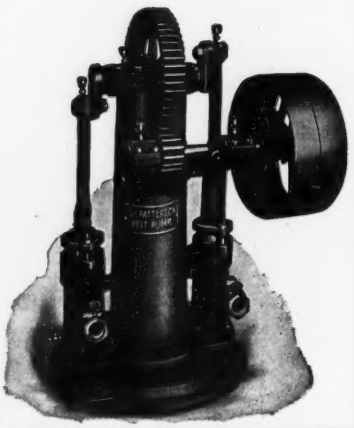

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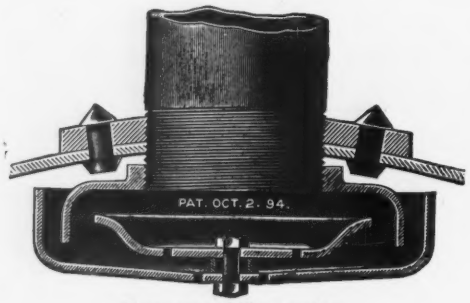
**used in boilers than all others.**

They insure dry steam, and protect your engine from water.

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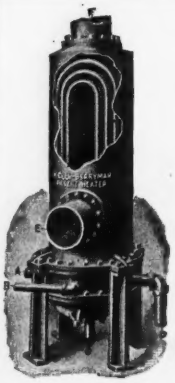

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**WATER TUBE AND STEAM TUBE**

Cast Iron or Steel Shells. "U" Shaped Seamless Drawn Brass Tubes.

We Build Heaters for every Purpose and Condition

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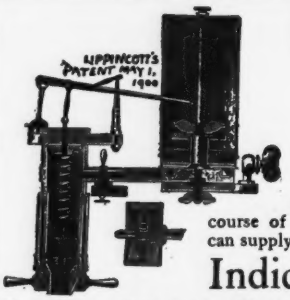


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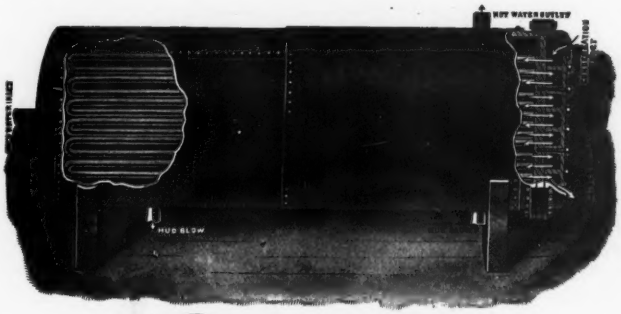

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The **Gleaner** represents the acme of perfection in feed water heating.

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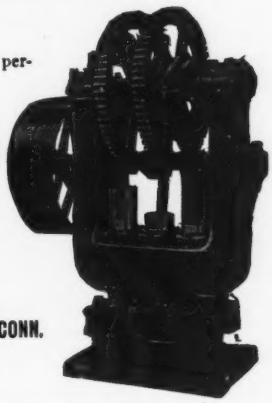
## Davis Triplex Power Pump

is a perfect type of the vertical triplex belt driven pump.



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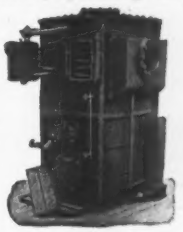
If you are going to run your plant condensing there are several important reasons why you should use a Cochrane Open Feed Water Heater, operating the pumps and small engines non-condensing and using the exhaust steam from these engines to heat the water in the Cochrane Heater.



Since a condensing engine has an efficiency of less than 15 per cent, the auxiliaries, if they are run off the main engine, will have the same efficiency, minus transmission losses; but if these auxiliaries are run non-condensing all the heat in the steam supplied to the auxiliaries which is not utilized in doing work can be conserved in the heater, giving the auxiliaries an efficiency of practically 100 per cent—instead of less than 15 per cent.

Then there is the higher vacuum you can obtain by having a Cochrane Open Heater to drive off the air and gases from the feed water—also the independence of the auxiliaries from the main engine—etc.

The new steam turbine plants are being equipped with open heaters—Cochrane Heaters. There's reason why.

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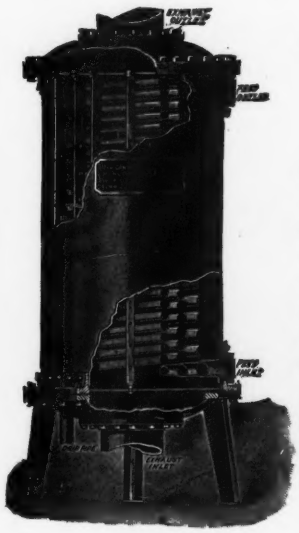

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**A Money Saver!**

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HARTFORD CONNECTICUT

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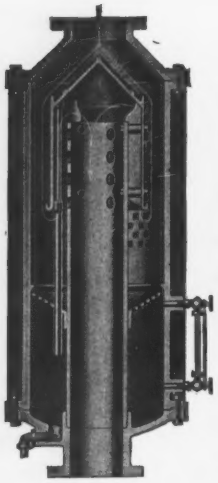

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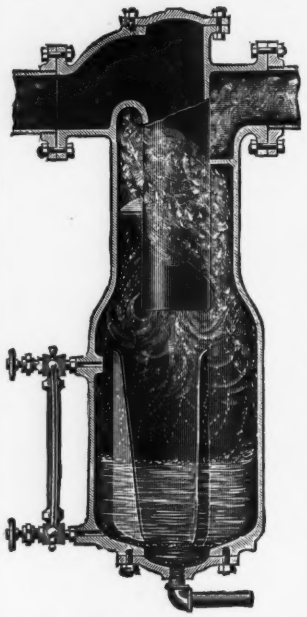

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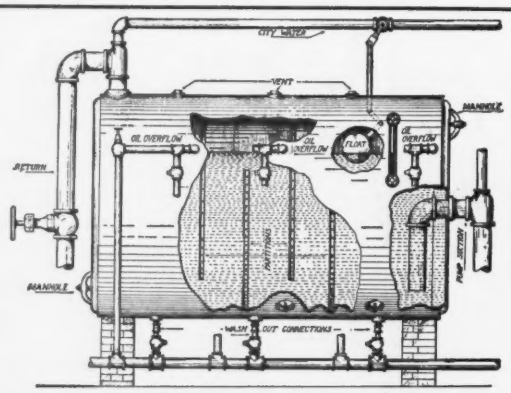


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may have developed some defects during the past winter, perhaps its efficiency was not as high as you desired on those few coldest days, or perhaps you have discovered that you are blowing a lot of water, oil and heat out into the sewer.

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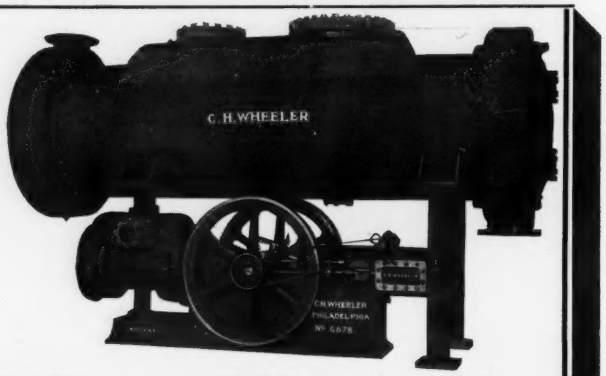


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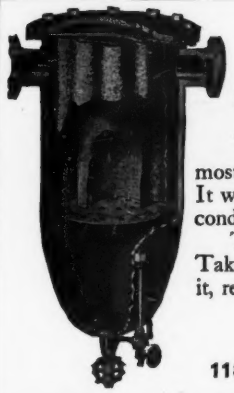

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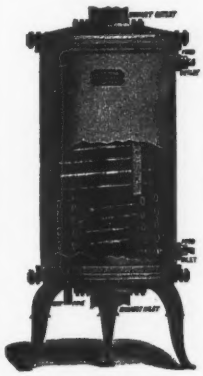

The National

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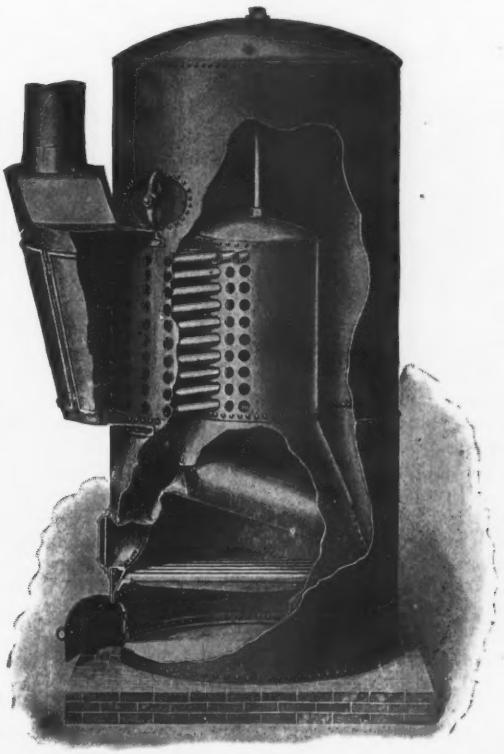

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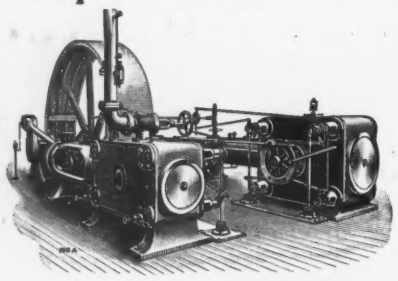

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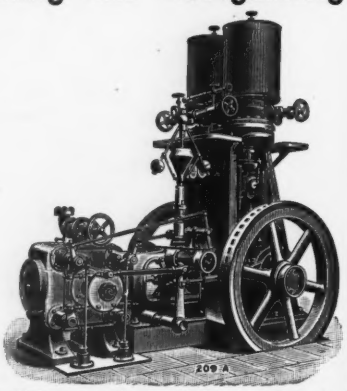

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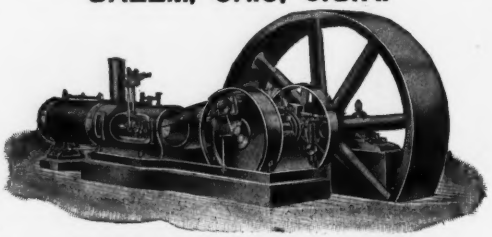

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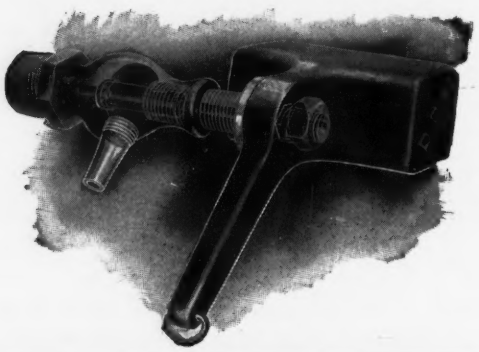

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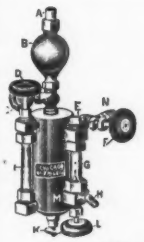


Sight Feed Lubricators have many advantages and features not found in other makes and are guaranteed to be strictly first class in every particular.

**READ WHAT A USER SAYS:—**

Crowley, La., Mar. 16, 1906

Messrs. Ohio Injector Company,
Wadsworth, Ohio

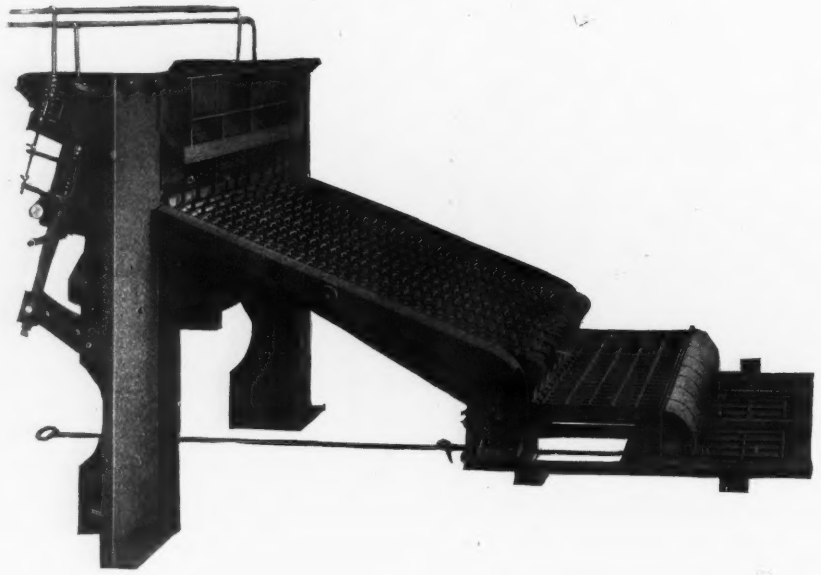
Gentlemen:—We have used in our own shop one of your Sight Feed Lubricators and have no hesitation in offering it to our customers **upon its merits.** It does what it is intended to do perfectly. Yours very truly,

CHAMPION IRON WORKS, Ltd.
Ben Stagg, Sec. & Treas.

**We also manufacture the Chicago and Garfield Injectors and Ejectors for stationary and locomotive service. Send for Catalogue.**

**The Ohio Injector Company**
**2128 MAIN STREET, WADSWORTH, OHIO**

# Evey particle of black smoke that goes out of your chimney is fuel that should have been consumed in the furnace.



All smoke is wilful waste. Just step outside; look at your chimney a few minutes and watch the dollars roll away and also note the damage to your own building and those of the community by soot and coal dirt, remembering the while that you are the gentlemen who pays for both the smoke and the damage it does and that your coal man is collecting regularly.

# Wilkinson Automatic Stokers

will reduce the coal dealers bills, will abolish the smoke nuisance entirely and will save their cost times over. They feed the coal constantly, regularly and always in small quantities as required without opening the fire doors to admit injurious cold drafts on the boiler. They have a lot of other good features which we have not the space to tell you about here. If you are interested and wish to know more about them, write to us giving the number and size of boilers in your plant, and the kind of fuel you are using and we will give you some facts about the Wilkinson that will be worth a great deal to you.

## Wilkinson Manufacturing Co.

**BRIDGEPORT, - MONTGOMERY, COUNTY, PA.**

# HARRIS OILS

## Consult
## A Harris Catalog
### on the subject of Lubrication.

It is a question that is always in order, especially if you are in doubt as to the lubricants you are using giving you the best service from the standpoint of economy and efficiency.

## Harris Oils

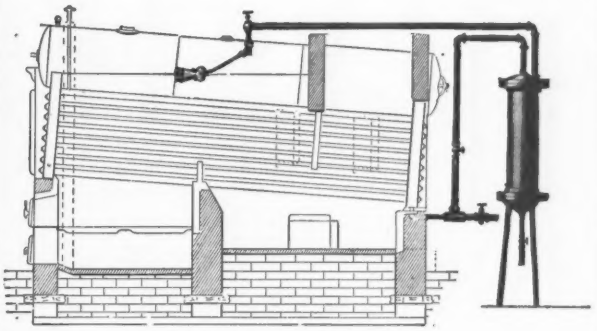
are made for the lubrication of every class of machinery and every type of engine.

A Harris Catalog of Petroleum Lubricating Oils, yours for the asking, gives full particulars in regard to their variety and uses.

We have also a proposition to submit to you in regard to your use of lubricants, that will interest you.

## A. W.
## Harris Oil Company
**320 South Water Street, Providence, R. I.**

Pacific Coast Agents.
Tatum & Bowen, 36 Fremont St., San Francisco.



# Its Easier
## much easier and much cheaper

to clean boilers, and keep them clean with this Automatic Skimmer than with chemicals or any other known device because the Skimmer removes the scale forming impurities from the water and deposits them in the filter outside the boiler, while under pressure.

**The whole operation is AUTOMATIC.**

Do not compare this Skimmer with others that you may have seen or heard of for there is no other Automatic Skimmer.

No matter how bad your water is. No matter how thick the scale is in your boilers

## The Buckeye
## Automatic Skimmer

will clean them and keep them clean all the time and not one cent of expense after the comparatively trifling first cost of installation.

Can you afford to continue buying barrel after barrel of chemicals forever and forever, or can you afford to buy expensive machines and pay men to grind out scale., to say nothing of the extra coal used while the scale is accumulating., when you can prevent it at such small cost.

**HUNDREDS OF THEM IN USE AND EVERY USER DELIGHTED WITH THE RESULTS**

We install them on trial and guarantee absolute satisfaction or no pay. After a trial you will not permit us to remove them.

**Our large new Catalogue tells the whole story. WRITE FOR IT.**

## The Buckeye Boiler Skimmer Co.
**Colburn Avenue. TOLEDO. OHIO**

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YOU HAVE ELEVATOR TROUBLES. WE
HAVE EXPERIENCE. LET'S SWAP.

**Keystone Elevator Inspection & Repair Co.**

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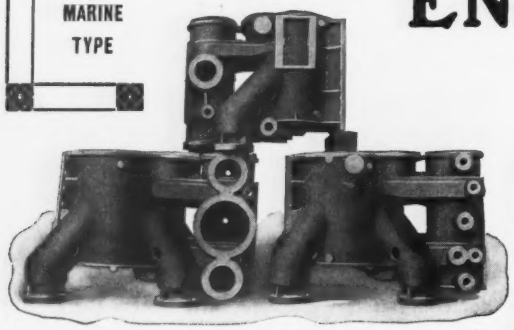
BELL PHONE—FILBERT 2258 KEYSTONE PHONE—MAIN 10-06

MARINE TYPE



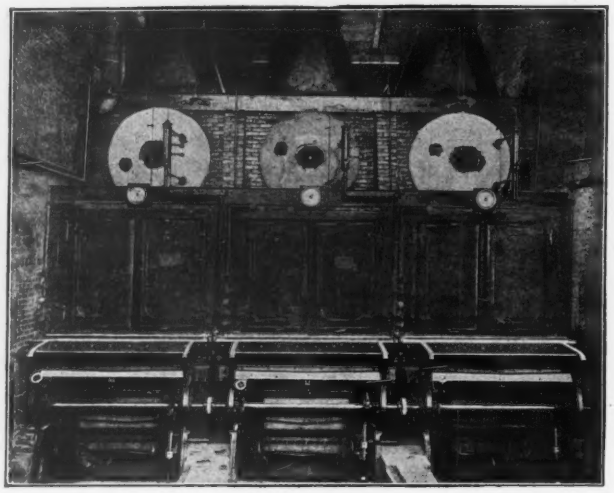
# ENGINE CYLINDERS

O-H-STEEL
HIGH PRESSURE
PIPE FITTINGS

THE JACKSON BELT LACER

BIRDSBORO STEEL FOUNDRY & MACHINE CO.
BIRDSBORO, PA.

# Does It Pay To Fire By Hand?



Does it pay to do **anything** by hand that can be done with a machine? The machine is always cheapest and best. Then why continue to kill men, waste fuel and annoy your community with smoke, when you can get a Wetzel Mechanical Stoker.

**ONE PATRON'S EXPERIENCE**

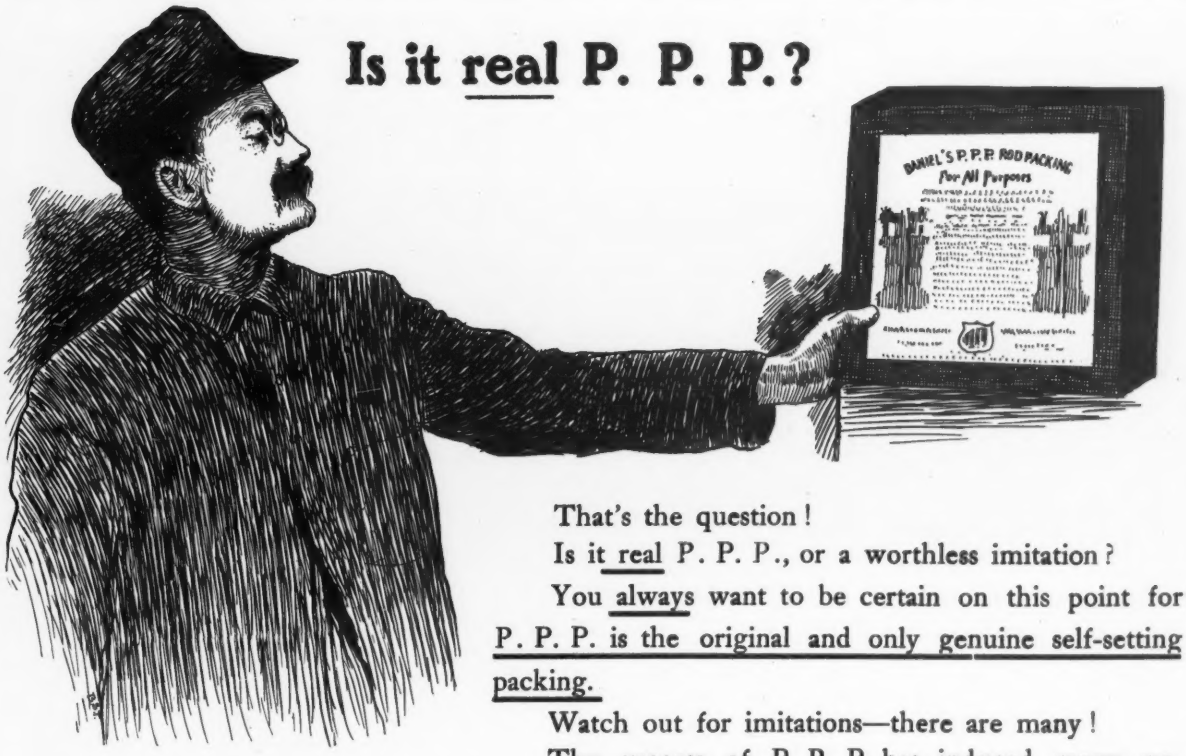
| | Hand Firing Old Method | | Wetzel System 18 Stokers | | Aver. monthly Saving |
|---|---|---|---|---|---|
| | Men | Wages | Men | Wages | in Wages |
| Firemen . . . . | 23 | $1,455 85 | 8 | $571 43 | $884 42 |
| Water Tenders . | 3 | 224 50 | 2 | 151 90 | 72 60 |
| Totals . . . . . | 26 | $1,680 35 | 10 | $723 33 | $957 02 |

There was also a saving of over 10 per cent in fuel to say nothing of the saving to the boilers. Isn't this case worth investigating.

**OUR LARGE CATALOGUE IS FREE TO YOU**

THE WETZEL MECHANICAL STOKER CO. 147 East State Street, Trenton, N. J.

# Is it real P. P. P.?




That's the question!

Is it real P. P. P., or a worthless imitation?

You always want to be certain on this point for P. P. P. is the original and only genuine self-setting packing.

Watch out for imitations—there are many!

The success of P. P. P. has induced many unscrupulous makers to offer so called "diagonal" and "combination" packings. They are fixed up to look like P. P. P.—and even the boxes are deceiving.

If you want real

# P. P. P. Rod Packing

the packing that won't keep you working everings and Sundays—the packing that will save you work, and your employer money—then insist on real P. P. P. You will know it from all others for the labels on the box and the muslin wrapper bear our registered Trade Mark with the signature of C. A. Daniel, across the face. Only the packing so stamped is real P. P. P.

In our booklet we prove that P. P. P. saves you work, and enables you to take life easy during the hot weather. We send it to you—when you send us the coupon.

*The* **Quaker City Rubber Co. Philadelphia**

Gentlemen:—Please send me your booklet proving that P. P. P. will save work.

Name _____

St. and No. _____

City _____ State _____

Occupation _____

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Practical Engineer

## Quaker City Rubber Co.

PHILADELPHIA, PA.

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GENERAL MACHINISTS.

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# Repairs to Steam Engines, Steam Pumps and other Power Plant Equipment is our Specialty.

If your engine or pump breaks down, day or night, no matter what the conditions are, or where you are located, send for us. We have the largest force of expert mechanics and the largest assortment of special repair tools and machinery to be found anywhere in North America. We send the men and the tools and the machines direct to the job. You don't need to dismantle your heavy engines and pumps, we do the work on the spot.

But don't wait until your engine breaks down. An ounce of prevention is better than a pound of cure, let us keep your plant in repair all the time, the saving in fuel will more than pay you. We rebore cylinders of any size in position and we have a special machine for reseating valves in position.

**SOME OF OUR OTHER SPECIALTIES**

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Send for our Book of Useful Hints for Engineers.

Dynamo Commutators Turned Off Without Removal.
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Portable Planer for Facing Off all Sizes of Hammer Blocks in position. All kinds of Steam Hammer Repairs.
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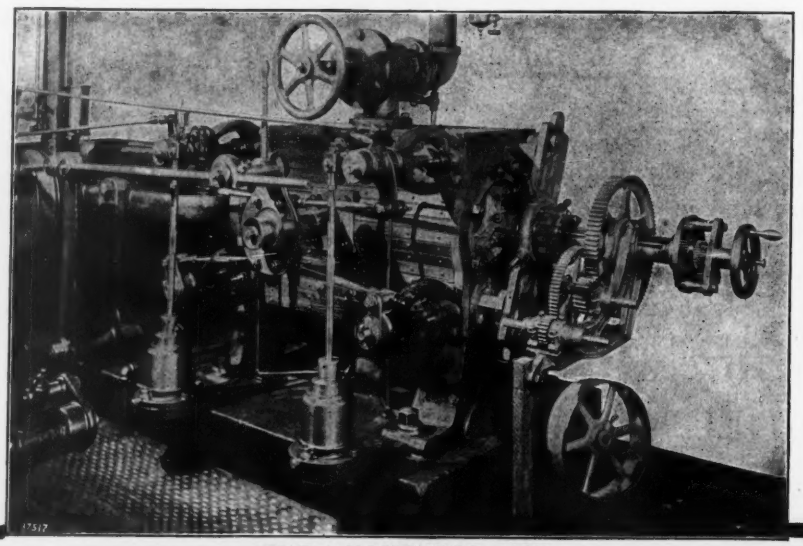

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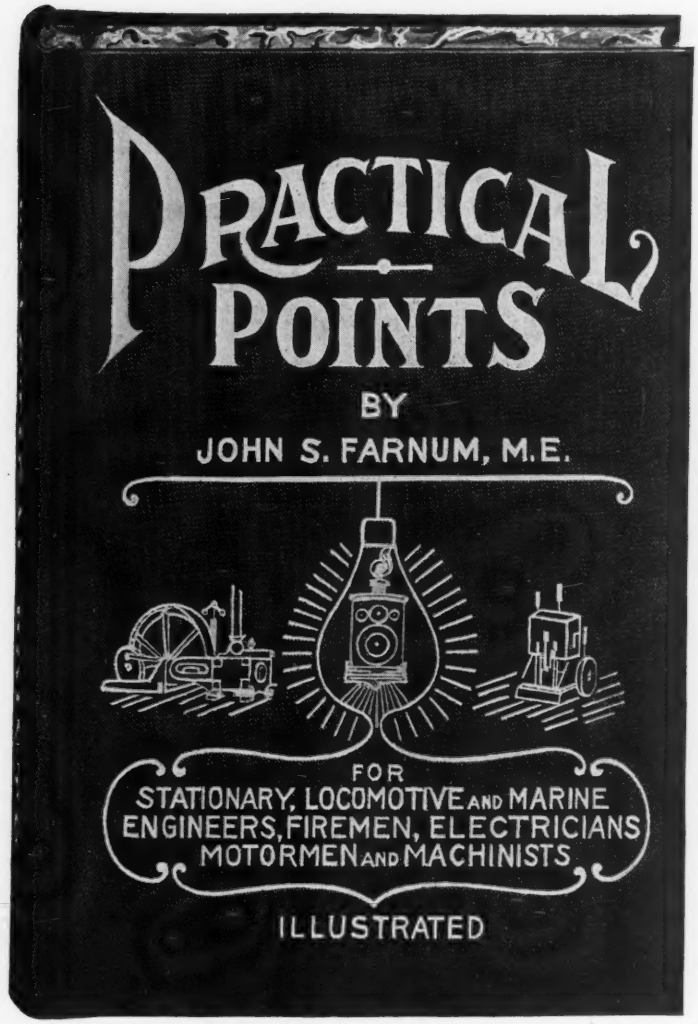
THE UNDERWOOD WAY




You never can tell what you CAN'T do until you try.

This book will tell you how to do things you can't do now.

**You can have it FREE**

**CUT OUT** a piece of scale from your boilers.

**CUT OUT** the coupon below and send it to us with the scale.

We will send you a Certificate of Analysis of the scale along with the book free of charge. We will also show you how you can get rid of scale by using

# Lord's Boiler Compounds

## GEO. W. LORD COMPANY,

**2238-50 North 9th Street, PHILADELPHIA, PA.**

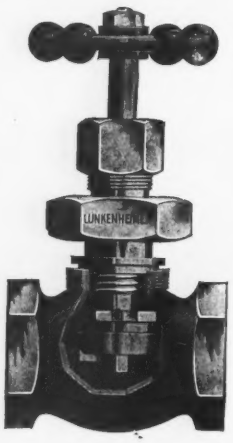
To
**Geo. W. Lord Co.**
**2238-50 N. 9th Street,**
**Philadelphia, Pa.**

Gentlemen: I am sending you a sample of scale from our boiler. You are to analyze it, and send me, free of charge, a certificate of analysis and the book.

*Number of boilers in use*_____
*Capacity of each boiler*_____
*Frequency of cleaning boilers*_____
*Frequency of opening the blow-off during working hours*_____ *River or other source of water supply*_____
*Boilers are used about*_____ *hours out of 24*
*Coal burned per day*_____
*Water evapo ated per day*_____
*Name*_____
*Street and Number*_____
*City*_____ *State*_____
*Firm's Name*_____
Date_____

Prac. Eng.

# LUNKENHEIMER REGRINDING VALVES




STANDARD AMONG STEAM USERS FOR HALF A CENTURY

NO ADDITIONAL PARTS REQUIRED TO REPAIR THEM WHEN WORN

A FEW MINUTES SPENT IN REGRINDING AND THEY ARE AS GOOD AS NEW

If Your Local Dealer Cannot Furnish them, Notify us

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Largest Manufacturers of High-Grade Engineering Specialties in the World.

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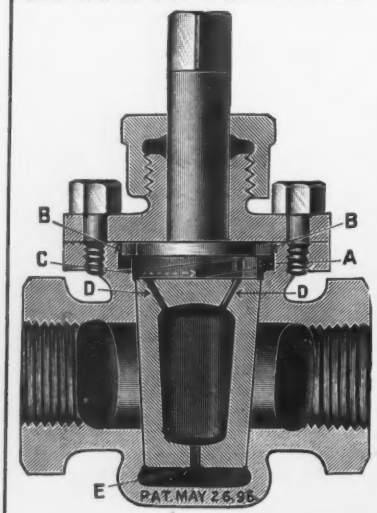
We Manufacture a Complete Line of Brass and Iron Globe and Gate Valves, Mechanical and Hydrostatic Lubricators, Oil and Grease Cups, Injectors, Ejectors, Whistles, Water Columns, Gauges, Pop Safety and Relief Valves, Etc. 2 P. E.

# Homestead Valves

**are built for hard service and satisfaction.**




The Homestead Straightway Valve shown herewith is so constructed that when it is closed it is at the same time forced firmly to its seat. It doesn't leak or stick. No better valve was ever made. It is made in all sizes up to 6 inches and for all pressures up to 5000 lbs. per sq. inch.

**Write for Catalogue**

**Homestead Valve Manufacturing Co.**

Brass Founders P. O. Box 1754 PITTSBURG, PA. Works at Homestead, Pa.

E. M. Dart Mfg. Co., Providence, R.I. Brogan & Co., Phila., Pa.
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Geo. C. Johns, New York W. A. Case & Son Mfg. Co., Buffalo, N.Y.
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# DO YOU WANT TO MAKE MONEY?

NO HOT AIR. NO HOLES IN THE GROUND.

A few shares of the stock of a company for sale at par, $1.00 which will enable you to participate in the profits derived from the handling of a number of inventions.

WRITE FOR INFORMATION

**INDUSTRIAL ENGINEERING CO.**

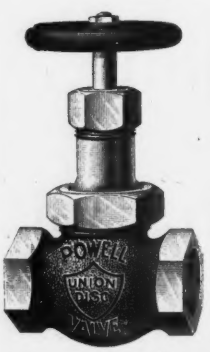
805 Provident Building, Philadelphia, Pa.

THE COMING VULCANIZED DISK VALVE IS THE

**POWELL**

# "UNION DISK"

FOR MEDIUM STEAM PRESSURE OR HOT WATER HEATING.




It is a radical departure in the construction, bonnet, and rigging being attached to the body by a ground Union joint, easily removed without injury to the Hexagon Nut. It is a pleasure to take the **Powell Union Disk** apart to get at the disk and seat, **its so different with other makes.**

Send for circular fully describing its peculiar merits, or better still, for sample Valve for trial. Manufactured by

***The* Wm. Powell Co., Cincinnati, O.**

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Have introduced Chemistry in the scientific, correct and economical treatment of boiler waters. Gallon samples of the feed water are analyzed from time to time, and the treatment furnished constantly meets requirements in the prevention of scale, corrosion, foaming or such troubles as each particular water may produce.

DEARBORN TREATMENT will positively keep your boilers clean and well preserved.

DEARBORN TREATMENT is made on such lines that the quantity required to treat each thousand gallons of water is small, consequently its use is economical.

You are further assured that a house of chemical standing will use no materials that in themselves would be injurious to your boiler plant.

If you have not adopted Dearborn Water Treatment as thousands have done, send us gallon of water for analysis and proposition.

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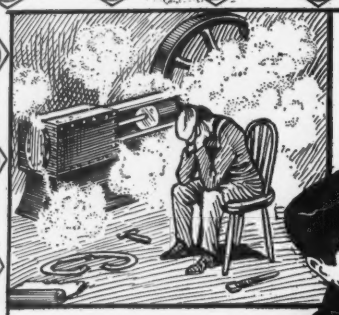
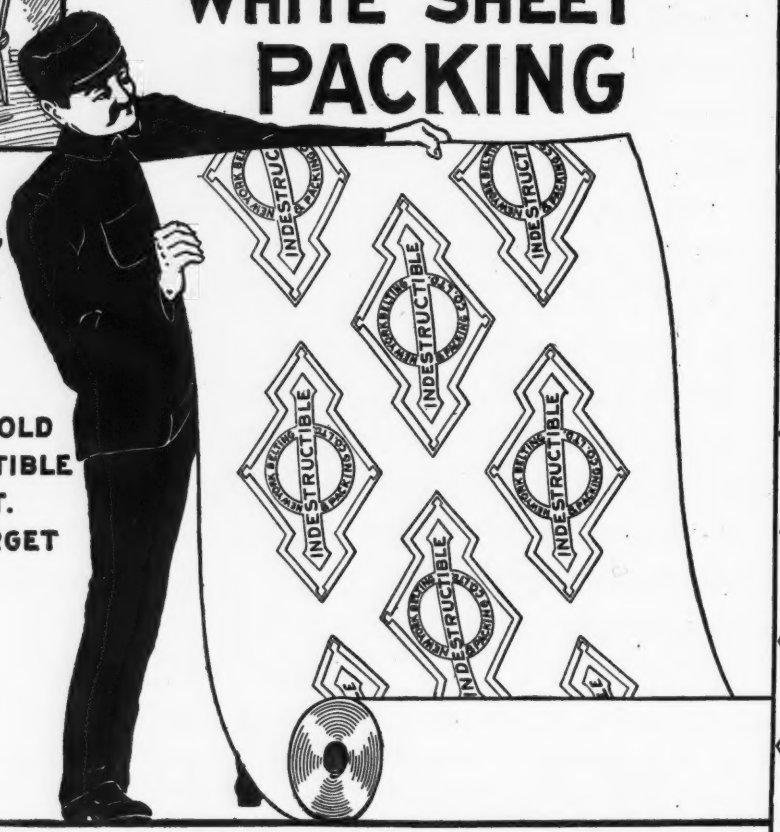


# INDESTRUCTIBLE WHITE SHEET PACKING

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HERE YOU ARE OLD MAN, INDESTRUCTIBLE DONT BLOW OUT. USE IT AND FORGET THE PAST.

MANUFACTURED AND PATENTED EXCLUSIVELY BY

## NEW YORK BELTING & PACKING CO., LTD.

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